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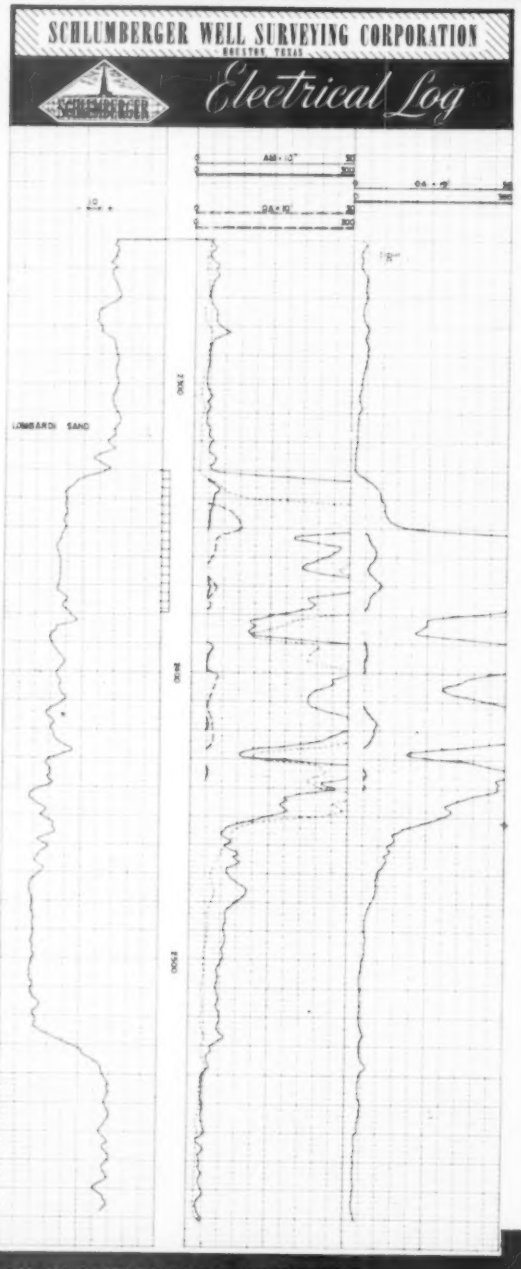
MIOCENE SAND-LOWER MONTEREY IN SAN ARDO FIELD MONTEREY COUNTY, CALIFORNIA

17

Mud (Quebracho, Gel):
R_m = 2.8 ohms at BHT
Bit Size: 10½"
Spacings: AM = 10"
AO = 10'
AO' = 19'



LOG ANALYSIS

1) Water saturation S

R_w 2.5 ohms in sand below water level.
R_t = 55 ohms

$$S = \sqrt{\frac{2.5}{55}} = 21.5\%$$

2) Formation water resistivity R_w

$$SP = -70 \log_{10} \frac{R_m}{R_w} = -54 \text{ mv.}$$

$$R_w = \frac{2.8}{6.0} = 0.47 \text{ ohm at BHT, or } 520 \text{ G/G}$$

3) Porosity p

$$F = \frac{R_o}{R_w} = \frac{2.5}{0.47} = 5.3$$

$$p = \sqrt[m]{\frac{1}{F}} = 38\% \text{ for } m = 1.7$$

CORE ANALYSIS

Average Porosity 40%
Average Water Salinity 465 G/G
Permeability 2,000 to 10,000 md.
Average Water Saturation for Producing Sand 10 to 20%

PRODUCTION RESULTS

Perforated: 2330' - 2379'
Potential: 150 BOPD, 11.5° API

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Editorial Comment—

OIL'S PERFORMANCE SUPPORTS ITS CASE

By Robert L. Minckler

President, General Petroleum Corp.

ONE of the most important problems facing the American oil industry today is our relationship with the American public, not as stockholders or employees or customers, but as a society. The social performance of the oil industry is under attack by enemies of great power and resourcefulness, and we must meet it. This can best be done by presenting our case in terms of what our industry has done for people.

Civilization has developed as man has learned to use energy. From the use of his hands he progressed to domestication of animals, to capture of the wind, to falling water, and within the past 200 years to the vast sources of energy in the engine and electricity. This revolution has extended so far in the United States that the use of energy in astronomic volumes has made it possible for us to be the most productive nation in the world, with the highest standard in world history. This living standard is reflected in the following comparison of per capita consumption of energy in 1937:

United States	7,000 KWH
United Kingdom	5,500 KWH
Western and Central Europe	3,630 KWH
France	2,800 KWH
Japan	1,250 KWH
Eastern and Southern Europe	827 KWH
China	170 KWH

In recent years, the oil industry has assumed the principal role in the supply of energy to the American people upon which our high productivity and living standards are based. The oil industry's output of energy in 1948 was 4.5 times what it was in 1920. In that year coal supplied 78 per cent of the nation's energy; it now supplies 38 per cent, while oil's share has increased in the same period from 18 per cent to 56 per cent. This outstanding record is ample evidence of how we have met our social obligation to produce an abundance of our products and make them readily available for the use of the people. We have the means to carry on this performance in the future.

Our products are of high quality. Steady improvement in their quality has made workable the improvements in engine design, the high speeds at which the machinery of industry can operate, and the other factors which steadily increase the per-man-hour production of our economic system.

The scope of our services has been constantly expanded by the development of new uses. There was synthetic rubber, toulene for explosives, 100-octane gasoline, and fuel for diesel engines. We are now making new fertilizers, alcohols, commercial solvents, plastic materials, synthetic fibers, nylon stockings, and thiopene for anti-histamine pills. These new uses are being found by 15,000 scientists and engineers in a $100 million research program.

From a paper presented to Division of Production, API, at the Rocky Mountain Spring Meeting in Casper, Wyoming, April 13, 1950.

We have maintained a reasonable price for our products. One of the standards for this is that prices should not be so high as to discourage use of the product. Differences in the prices of gasoline apparently do not affect demand for gasoline; the gasoline price war does not result in more gasoline sales. Ample fuel and cost of conversion from coal to oil seem to be greater factors in home heating than price, but the increase of 85 per cent in the number of domestic oil burners during the past eight years does not indicate that too high prices have retarded growth of demand.

The oil industry record is clear on profits. From 1929 to 1948, the 30 largest oil companies earned an average of 7.2 per cent of their invested capital per year, while the average earning of 218 large industrial corporations earned 9.0 per cent. In only two years, 1932 and 1948, did the rate of profit of the oil companies exceed that of the other companies.

THE enemies of the oil industry would have you think that our principal operation is plotting against the public welfare, and that most of us are busy most of the time taking bread out of the mouths of widows and orphans. As a simple fact, most of us are engaged in handling and moving about a very heavy, bulky, low-grade commodity. We search for it in the bowels of the earth, lift it up into tanks, pump it miles to a refinery, clean it up, mix it up, put it on a tank car, truck or ship, move it miles to a terminal, unload it and load it several times until it gets to the filling station. The station man puts it into the customer's tank, wipes his windshield, gives him air and water, and charges him three cents per pound. What other product that requires all this human labor and energy in handling can you buy for three cents a pound? Bread is about 20c, milk is about 15c, lumber is about 12c, an automobile about 80c. And that three cents is for gasoline; fuel oil is only one-fourth to one-half cent per pound, down in the range of prices of rock and gravel.

By any standard or test that can be applied, ours is an important industry which has served the public well. No one who has drilled as many dry holes as we have would pretend that no mistakes have been made in the oil business. But, on balance, the record of our industry is impressive. This record is outstanding in service to people.

This record should be the bulwark of our defense against attacks by persons with poltical motives and by bureaucrats who would disintegrate the oil industry and break it up into pieces. This record of social performance will support our case for the opportunity to be left free to try any new idea, free to succeed, free to fail, and free then to try it again. We should not ask for special privilege or position but should present our case in a dignified, factual manner and stand on it, for its strength will support us. ★ ★ ★

Methods of Treating Water For Flooding Purposes

By A. Richard Ellenberger*

WITH the introduction of water flooding as a means of forcing the residual oil from producing sands, the operator noted that the rate of intake diminished with the time over which the flood had been operated. As time went on, he observed that there was an initial fill-up period required before a pressure potential was developed by the injected water. It was difficult, however, to distinguish between decrease in the rate of intake as a consequence of the mechanism of the fill-up and that which arose because of chemical changes resulting from the character of the water. Only where conditions were so extreme that the intake rate diminished very rapidly did the character of the water used take on its proper importance in the mind of the producer.

The ideal flood water is one which does not react with the oil-bearing sand or any constituents normally contained in the sand; moreover, it must permeate the sand uniformly and readily. Whatever the ideal flood water may be, the operator is under the necessity of utilizing such water as is available upon the premises or which may be transported to the lease at reasonable cost. It is the part of wisdom, therefore, to produce from available supplies a water which most nearly approaches the conditions of the ideal flooding medium at a cost commensurate with the results obtained.

The original source of water in wells, in springs, or in streams is from precipitation onto the surface of the earth. In the interval in which it is in contact with the atmosphere, this pure distilled water dissolves carbon dioxide, oxygen and nitrogen from the air. In percolating through the surface of the earth and later in contact with deeper strata, soluble portions of the minerals composing the earth are dissolved. Sometimes this occurs with the aid of the dissolved gases which react with the minerals to convert them to compounds soluble in water. For example, dissolved carbon dioxide reacts with insoluble limestone converting it into soluble calcium bicarbonate. Carbon dioxide dissolved in rain water is much more active than when dissolved in water containing buffer salts. As the bicarbonate is formed thereby increasing the buffer content, the acidity of carbon dioxide solutions is reduced until eventually equilibrium is reached.

It is due to this solvent effect that waters contain bicarbonates, carbonates, sulfates, chlorides and nitrates of the various metals found in the earth's crust. The metals usually found are sodium, potassium, magnesium, calcium, iron and manganese. Carbon dioxide and hydrogen sulfide are also found in dissolved form. Since the last two are gases under ordinary conditions, their equilibrium with the other compounds present is dependent upon the conditions of temperature and pressure. Bringing such waters to the surface produces a considerable change in these conditions, and even though the water was originally in equilibrium as regards its various constituents, this equilibrium no longer exists under conditions found at the surface.

EQUILIBRIUM WATERS

An occasional water is so constituted that, even under surface conditions, equilibrium is actually or substantially maintained. The treatment under these circumstances is relatively simple. No iron needs to be removed and the only corrosion encountered is that due to dissolved oxygen, which is minor under equilibrium conditions.

But even though chemical equilibrium is already attained, it is necessary to insure that organisms, such as algae, fungi, and bacteria are removed. The growth of algae in tanks accessible to sunlight creates a residue in the water that can effectively close the sand face and seriously reduce the water input. Fungi have the same effect and certain bacteria give rise to serious corrosion in the lines between the treatment plant and the intake wells.

The treatment in this case consists of chlorination, coagulation, sedimentation, filtration and stabilization. The chlorine is applied before coagulation and filtration and persists after these operations are completed. Its effect is applicable both to algae and bacteria, but in cases where algae are chlorine-resistant, a small dosage of copper sulfate with the chlorine will remove the most refractory.

Stabilization of the equilibrium is accomplished by maintaining as little as one part per million of residual complex phosphate. As a result, contact with connate waters will not produce undesirable reactions. In addition, complex phosphates exert a protective effect on iron and steel apparently by the deposition of a film although there is no visible evidence of it.

Table I gives the analysis of a water of this type. This

Table I

Results are expressed in parts per million

pH		7.7
Carbon Dioxide	CO_2	7
Dissolved Oxygen	O_2	0
Color	*Pt*	3
Turbidity		1.1
Sulfates	SO_4	2.7
Manganese	*Mn*	0
Iron (Total)	*Fe*	0.1
Alkalinity	$CaCO_3$	139
Equilibrium Tests: Alkalinity		129
Equilibrium Tests: *pH*		7.7
Chlorides	*Cl*	110
Soap Hardness	$CaCO_3$	128
Silica	SiO_2	7
Calcium	*Ca*	54
Magnesium	*Mg*	9

*Manager, Bradford Laboratories, Inc., Bradford, Pennsylvania. Paper presented to the Illinois Basin Chapter, Petroleum Branch, AIME, March 9, 1950.

water, according to our procedure, is very close to equilibrium. The only treatment given it, apart from filtration, was the addition of chlorine and a minimum amount of complex phosphate.

No treatment had been given to this water prior to the institution of the procedure outlined above. The intake rate curve shows that intake rates have been maintained.

Examination of the lines which carry this water indicates that no deposition is occurring nor is the line undergoing detectable corrosion from the inside.

UNSTABLE WATERS

Instability Due to Calcium Bicarbonate

Waters flowing through strata containing calcium carbonate dissolved considerable amounts of this mineral as calcium bicarbonate.

$$\underset{\text{(Insoluble)}}{CaCO_3} + CO_2 + H_2O = \underset{\text{(Soluble)}}{Ca(HCO_3)_2}$$

This reaction is reversible and the escape of free carbon dioxide will result in the deposition of calcium carbonate as an insoluble residue. The *pH* of such waters is usually lower than that which would be found at equilibrium. This indicates more carbon dioxide than can be held in equilibrium by the calcium carbonate. This "aggressive" carbon dioxide, acting as an acid which is weak but effective, will attack either calcium carbonate or iron. By measuring the amount of bicarbonate produced as a result of bringing the water to equilibrium with additional calcium carbonate, the aggressiveness of the carbon dioxide may be determined. Analysis of the water makes it possible to ascertain the conditions under which equilibrium may be secured. This condition of equilibrium is affected by the temperature and by the amount and type of dissolved constituents present. Only a careful laboratory study of the water or waters to be treated will afford sufficient data on which to base a course of treatment adequately dealing with this problem.

In some instances, hydrated lime $Ca(OH)_2$ is used to adjust the alkilinity to the proper value; in others, caustic soda, $NaOH$, is used. The amount of chemical to be fed is computed from the laboratory data.

In some instances, no calcium carbonate is precipitated in the process, but in others there is a reduction in the total amount of the dissolved bicarbonate as the alkalinity increases. This means that the filter, which should invariably be used, may be called upon to remove calcium carbonate as well as other suspended matter. The use of complex phosphate for the control of stability is even more critical in this case than in the preceding one but the nature of the action of these phosphates is such that the dosage need not necessarily be increased. Attention must be paid to the removal of algae and bacteria in every instance and the effectiveness of their control will, in a considerable measure, affect the success of the treatment in maintaining or increasing intake rates.

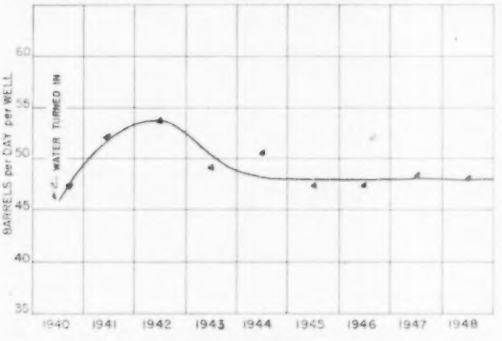

FIG. 1 — DAILY AVERAGE INTAKE PER WELL BY YEARS — 28 INTAKE WELLS.

Table II

Results are expressed in parts per million

pH		6.3
Carbon Dioxide	CO_2	160
Dissolved Oxygen	O_2	0
Color	*Pt*	1
Turbidity		0.8
Sulfates	SO_4	3.5
Manganese	*Mn*	0
Iron (Total)	*Fe*	0.05
Alkalinity	$CaCO_3$	71
Equilibrium Tests — Alkalinity		166
Equilibrium Tests — *pH*		7.4
Chlorides	*Cl*	58
Soap Hardness	$CaCO_3$	100
Silica	SiO_2	14
Calcium	*Ca*	24
Magnesium	*Mg*	10

Table II gives the analysis of a water low in *pH* but free from manganese and very low in iron. Its corrosive character was indicated by an increase in the iron content of the water in the lines as the distance from the plant increased. Treatment consisted of feeding an alkali, chlorine, and complex phosphate. Following the treatment, corrosion of pipe lines was reduced to practically zero. Shortly after the initiation of this treatment, an increase in intake rates was noted with a subsequent increase in production.

Waters Containing Iron and Manganese

It is not an infrequent occurrence for ground waters to contain iron and manganese bicarbonate which are held in solution by free carbon dioxide in much the same manner as calcium bicarbonate. There are, however, some differences between the two cases. The decomposition of the bicarbonate through loss of carbon dioxide occurs more readily and the resulting carbonates hydrolyze to form hydroxides. These are in turn oxidized by the dissolved oxygen in the water to form hydrated ferric oxide and hydrated manganese dioxide. These constitute a gelatinous, adherent precipitate which is particularly resistant to the flow of water when deposited upon the sand face. In addition, soluble iron and manganese support the growth of strains of bacteria which may include Creno-

Table III

Results are expressed in parts per million

pH		6.7
Carbon Dioxide	CO_2	25
Dissolved Oxygen	O_2	0
Color	*Pt*	1
Turbidity		1.4
Sulfates	SO_4	18
Manganese	*Mn*	0
Iron (Total)	*Fe*	3.0
Alkalinity	$CaCO_3$	69
Equilibrium Tests — Alkalinity		112
Equilibrium Tests — *pH*		7.3
Chlorides	*Cl*	1
Soap Hardness	$CaCO_3$	120
Silica	SiO_2	6
Calcium	Ca	27
Magnesium	*Mg*	4

Table IV

Results are expressed in parts per million

pH		5.9
Carbon Dioxide	CO_2	90
Dissolved Oxygen	O_2	0
Color	*Pt*	1
Turbidity		1.5
Sulfates	SO_4	36
Manganese	*Mn*	15
Iron (Total)	*Fe*	7.5
Alkalinity	$CaCO_3$	35
Equilibrium Tests: Alkalinity		123
Equilibrium Tests: *pH*		6.8
Chlorides	*Cl*	290
Soap Hardness	$CaCO_3$	360
Silica	SiO_2	18
Calcium	*Ca*	78
Magnesium	*Mg*	27

thrix. These proliferate as a fibrous mass in which the metal oxides are incorporated. To prevent their growth, the complete removal of iron and manganese is necessary. Failure to do this may result in very serious trouble.

The first step in their elimination calls for the reaction of the carbon dioxide with a basic substance, either lime or caustic soda. Since deep-well waters do not normally contain dissolved oxygen, and do not acquire it if the water is produced with turbine pumps, chlorine must be introduced as an oxidizing agent to convert both metals to their higher oxides. This function is in addition to its normal and exceedingly valuable one of eliminating bacteria, algae and fungi.

Where several parts per million of iron are present, it is often necessary to add any other coagulant since ferric hydroxide performs this function. When filtration is properly conducted, when filter beds are maintained in good condition and when the proper dosages of chlorine, prosphate and lime are added, iron and manganese-bearing waters will be finished with a clear and brilliant appearance that presages very satisfactory flood performance. Following filtration, the water requires the same treatment with complex phosphate accorded to the previous cases.

Table III shows a water which contains no manganese but a considerable amount of iron. By feeding chlorine and the proper quantity of alkali, excellent iron removal was obtained. At least 90 per cent of the iron had been sedimented before the water went to the filter.

Table IV gives the analysis of a water which proved to be very corrosive to steel lines. In addition, it contains large amounts of iron and manganese. The water is treated with lime, chlorine and a very small amount of phosphate before settling. This results in more complete iron and manganese removal. All of the manganese and all except 0.2 ppm. of iron is removed by sedimentation prior to filtering. After filtering, a small amount of complex phosphate is added to keep calcium carbonate in solution. This water has proved to be outstanding in recovering oil from the Bradford sand.

Waters Containing Dissolved Gases

It has been pointed out that the presence of carbon dioxide lowers the *pH* of water and causes it to be corrosive. Another dissolved gas, hydrogen sulfide, may have even more serious consequences. Hydrogen sulfide reacts with iron directly forming hydrogen gas and black, insoluble ferrous sulfide. The insolubility of the ferrous sulfide causes the reaction to proceed far toward completion. The exposed metal is protected from oxidation and the surface of the pit formed by corrosion has a shiny, silvery appearance. Because of its rapid action on metallic surfaces and the formation of a considerable accumulation of solid residue, hydrogen sulfide must be removed before it has the opportunity to react. Like carbon dioxide, hydrogen sulfide may be largely removed by aeration but the introduction of oxygen into the water during the process creates new problems of its own.

Chlorine in its role as oxiding agent converts hydrogen sulfide into chlorides and sulfates. It is essential in this, as in all other cases, to control the dosage of chlorine accurately and a chlorinator for this purpose needs to be installed.

Table V gives the analysis of a water which requires fine adjustment of chemical dosage in order to achieve a satisfactory flooding medium. The hydrogen sulfide is oxidized by chlorine while the iron is precipitated by addition of alkali. The use of lime is necessary in this case because of the instability of the original water. Complex phosphate for after-treatment is vital to the success of this operation and only by its use could this water be made available for flooding purposes.

USE OF PRODUCED WATERS

In many cases, the use of produced water as flood medium solves the vital problem of brine disposal while it provides a source of supply. Brine offers some advantages since it has the same composition as the connate water. It may not be assumed, however, that it will be constant in composition during the period of storage and reinjection unless a closed

Continued on Page 5, Section 2

Table V

Results are expressed in parts per million

pH		7.0
Carbon Dioxide	CO_2	120
Dissolved Oxygen	O_2	0
Color	*Pt*	3
Turbidity		2.6
Sulfates	SO_4	750
Manganese	*Mn*	0
Iron (Total)	*Fe*	6.5
Alkalinity	$CaCO_3$	487
Equilibrium Tests: Alkalinity		461
Equilibrium Tests: *pH*		6.7
Chlorides	*Cl*	652
Soap Hardness	$CaCO_3$	2100
Silica	SiO_2	24
Calcium	*Ca*	395
Magnesium	*Mg*	105

Table VI

Results are expressed in parts per million

pH		7.3
Carbon Dioxide	CO_2	12
Dissolved Oxygen	O_2	0
Color	*Pt*	25
Turbidity		11.5
Sulfates	SO_4	640
Manganese	*Mn*	0
Iron (Total)	*Fe*	2.0
Alkalinity	$CaCO_3$	143
Equilibrium Tests: Alkalinity		134
Equilibrium Tests: *pH*		7.3
Chlorides	*Cl*	4750
Soap Hardness	$CaCO_3$	1240
Silica	SiO_2	9
Calcium	*Ca*	525
Magnesium	*Mg*	96

Technical Notes

INFLUENCE OF DIFFERENT TYPES OF FORMATION WATERS ON DISINTEGRATION OF CEMENTS

ROSCOE C. CLARK, JR., STANOLIND OIL AND GAS COMPANY, TULSA, OKLAHOMA

ABSTRACT

A study of the effect of various corrosive waters on five different types of cements indicated that those cements containing less than 5 per cent tricalcium aluminate were the most resistant to corrosion.

INTRODUCTION

Oil field experience indicates that some formation waters are excessively corrosive to some cements. A study has been made to determine the most corrosive waters and the relative resistance of various types of cement to these corrosive waters.

PROCEDURE

This study of the corrosion of cement was limited to an evaluation of the effect of various corrosive waters on five different types of cements. A determination was made of the types of cements which offer the greatest resistance to corrosion and of the chemical contents of waters found to be the most destructive to cements.

The laboratory tests were conducted by immersing small cylinders of 20 samples of set cement in various corrosive waters. The initial mixing of most of the cement slurries was done using Tulsa tap water as the mixing water; however, a few of the slurries were mixed using a sulfate water as the mixing water. When the 20 samples had been immersed for a period of nine months, they were removed from their corrosive baths, inspected and photographed.

The field tests were conducted by placing ten cement specimens, each contained in a screen wire thimble, in the gas anchors of insert pumps in wells in six different fields. The specimens were observed whenever it was necessary to pull the pumps and were returned to the laboratory when deterioration had reached a serious state.

EXPERIMENTAL RESULTS

In both the field and laboratory tests the resistance of the different cements to corrosion was determined by the condition of the samples and the number of samples of each that were in good condition at the end of the immersion period. Table I lists the various cements tested in the order of their resistance to corrosion with the most resistant at the top and the least resistance at the bottom.

An analysis of Table I reveals that the upper half of the table predominates in slow set and sulphate resisting cements (low $3CAO.Al_2O_3$ content) while in the lower half the portland and high early strength cements are in the majority. Of the last two the high early strength cements appear to offer less resistance to sulfate water corrosion.

An investigation of the composition of the cements listed in Table I indicated that as a general rule the cements containing less than five per cent tricalcium aluminate will exhibit the greatest resistance to corrosion.

The destructive action of various corrosive waters was compared by listing the waters in the order of those containing the largest number of samples that failed completely. These ratings are presented in Table II with the most corrosive waters listed first and the least corrosive last.

Figs. 1 and 2 show the end views of cement samples which had been immersed in the baths of five per cent $MgSO_4$ water and the five per cent Na_2SO_4 water respectively in the laboratory. These pictures are representative of the results obtained and present a pictorial evaluation of the corrosive resistance of various types of cements.

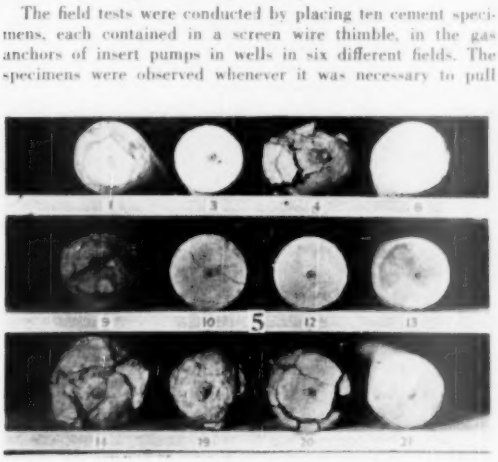

FIG. 1 — SLOW SET CEMENTS — 6, 12, 13; STANDARD PORTLAND CEMENTS — 1, 10, 20, 21; HIGH EARLY STRENGTH CEMENTS — 3, 4, 9, 14, 19; SAMPLES OF CEMENTS IMMERSED IN THE FIVE PER CENT $MgSO_4$ BATH FOR NINE MONTHS.

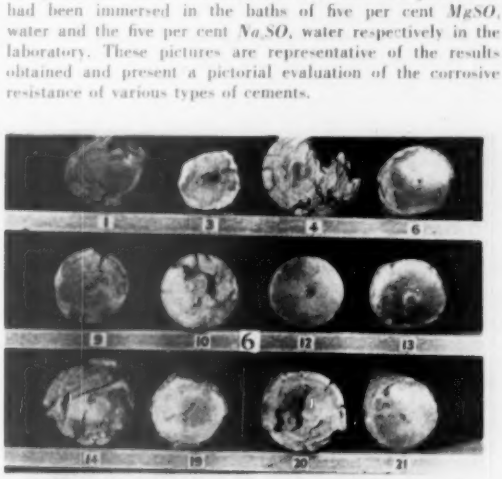

FIG. 2 — SLOW SET CEMENTS — 6, 12, 13; STANDARD PORTLAND CEMENTS — 1, 10, 20, 21; HIGH EARLY STRENGTH CEMENTS — 3, 4, 9, 14, 19; SAMPLES OF CEMENTS IMMERSED IN THE FIVE PER CENT $NaSO_4$ BATH FOR NINE MONTHS.

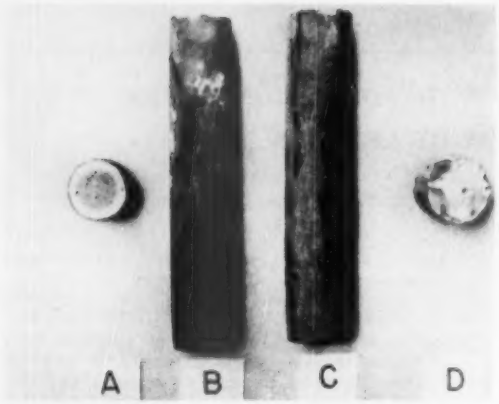

FIG. 3 — RESULTS OF FIELD TESTS. SAMPLE A, TYPE II CEMENT; SAMPLE B, SLOW SET CEMENT; SAMPLE C, MISCELLANEOUS CEMENT; SAMPLE D, HIGH EARLY STRENGTH CEMENT.

Figs. 3 and 4 are representative of the results obtained from the field tests. In evaluating the effects of these formation waters on cement samples it should be noted that the specimens were placed in the well in such a position that they were exposed to extremely large volumes of formation water. Cements exposed to smaller quantities of water in relation to the cement volume under less violent agitation should withstand corrosive waters much longer than the time indicated by these tests. It is believed, therefore, that cement placed in a well should probably not corrode rapidly until a channel is developed through which formation waters can pass. After a channel has been developed, however, the rate of cement corrosion may be expected to be on the order of that shown in Figs. 3 and 4.

Table I

Resistance of Cements to Corrosion

Cement	Number of Sound Samples: Out of 17 Lab. Tests Each with a Different Corrosive Water	Out of 6 Field Tests	Per Cent Tricalcium Aluminate
A-1	17	4	4.1
B-1	15	3	
A-2	15	3	.23
A-3	14	3	2.0
C-1	13	3	
C-2	13	2	
A-4	12		
C-3	12		9.5
A-5	11		3.5
A-6	11		
C-4	11		
C-5	7		
D-1	6	2	10.95
C-6	6	2	13.69
C-7	6		10.10
D-2	5		
D-3	5		12.20
C-8	5		
D-4	5	1	12.4
D-5	0	0	

Key: A — Slow Set Cements
B — Sulphate Resisting Cements
C — Standard Portland Cements
D — High Early Strength Cements

Table II

Order of Corrosive Effects on Cement

Rating	
1	Two per cent $MgSO_4$ two per cent Na_2SO_4 $CaSO_4$ (Sat. Soln) charged with H_2S gas
2	Five per cent $MgSO_4$
3	Five per cent Na_2SO_4
4	Tulsa city water (cement mixed with water containing 0.1 per cent $MgSO_4$)
5	Saturated solution of $CaSO_4$
6	Tulsa city water (cement mixed with water containing 0.5 per cent $MgSO_4$)
7	Tulsa city water (cement mixed with water containing 0.05 per cent $MgSO_4$)
8	Formation water from Salt Creek, Wyoming Field. Sulphates 1,619 PPM
9	Tulsa city water charged with H_2S gas
10	Two per cent $MgSO_4$ two per cent Na_2SO_4 $CaSO_4$ (Sat. Soln)
11	Formation water from Goldsmith, Texas, Field. Sulphates 5,434 PPM
12	Formation water from Hobbs, New Mexico, Field. Sulphates 1,590 PPM
13	Formation water from Abell, Texas, Field. Sulphates 3,895 PPM
14	Formation water from E. Hackberry, Louisiana, Field. Sulphates 121 PPM
15	Formation water from Polo Field. Sulphates 9,713 PPM
16	Formation water from Hastings, Texas, Field. Sulphates 70 PPM

SUMMARY

In summation, it is evident from both laboratory and field tests that cement corrosion is a real problem in areas where the formation waters to which cement will be exposed contain any appreciable quantities of sulfates or sulfides, but that the corrosion will probably not be prohibitive if low tricalcium aluminate content cements are used. * * *

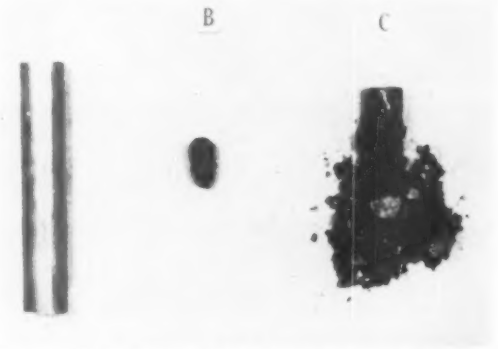

FIG. 4 — RESULTS OF FIELD TESTS. SAMPLE A, METALLIC CYLINDER STOCK REPRESENTING THE ORIGINAL SIZE OF THE TEST SAMPLES; SAMPLE B, SLOW SET CEMENT; SAMPLE C, TYPE II CEMENT.
CUTLINES—WATER FLOOD ARTICLE

INTERPRETATION OF CAPILLARY PRESSURE DATA

W. R. PURCELL, SHELL OIL CO., HOUSTON, TEX., MEMBER AIME

In a previous technical note[1] by Walter Rose, evidence is offered in support of the contention that "the possibility of describing oil recovery features in terms of capillary pressure phenomena has not been established entirely." It is not the purpose of this note to present further discussion of this possibility but rather to point out that the argument presented there does not appear to be generally valid.

In the cited note[1] reference is made to the experiments of Welge[2] wherein it was shown that when water was displaced by oil from a core the pressure in the water phase was less than in the oil phase but that when this oil was then produced by water drive the pressure in the water phase was greater than in the oil phase. Rose has concluded from these observations that conditions of static equilibrium did not obtain since the fluid saturations were such that phase discontinuities seemed unlikely. The argument from which this conclusion was drawn is based on the contention that "the pressure is *always* greatest in the non-wetting phase at each static interstitial interface of contact with the wetting phase." This premise appears to have been reached from a consideration of capillary phenomena in cylindrical tubes, although it may also hold for other types of pore geometry, but as will be shown below it does not hold for *all* pore shapes and hence is not generally applicable.

Since the pore structure of porous media such as reservoir rocks is in general so complex as to defy exact description, it is undoubtedly of great value to establish a model in terms of pore shapes of known geometry, provided of course that the limitations of the model are recognized. That the limitations of the capillary, or cylindrical, tube model have not always been fully recognized will be evident from the following discussion of a pore of different shape but one which may as logically be considered as the capillary tube.

The pore space to be considered is that shown in Fig. 1, which may be thought of as the "hole in a doughnut."* Consider the interface, *A-B-A'*, between two immiscible fluids, P_1 and P_2, which interface meets the solid along a line, *A-C-A'-C'*. The interface *A-B-A'* is the surface of a spherical segment† while the line of mutual contact between the three phases (*A-C-A'-C'*) is a circle. The contact angle, θ, will be determined by the relative magnitudes of the interfacial tensions between the solid, P_3, and fluid, P_1, and fluid, P_2, between the solid and fluid, P_3, and between the two fluids. If the contact angle as measured through fluid P_1 is less than 90° (as in Fig. 1) then P_1 is said to be the wetting phase; if the contact angle with respect to P_1 is greater than 90° it is said to be the non-wetting phase. The sign of the difference in pressures of the fluids, P_1 and P_2, at equilibrium will not be determined solely, however, by the wetting characteristics of the solid, as would be the case in a cylindrical tube, but will depend also on the position of the interface within the pore. For example, when the interface is in the position *A-B-A'*, determined by the angle, α_1, (see Fig. 1), it will be convex with respect to fluid P_2 and the pressure in this phase will be less than that in fluid P_1. If the interface is in a position represented by α_2, however, it will be flat and no pressure difference will exist between the two fluid phases. Finally, if the position of the interface is defined by α_3, it will be concave with respect to P_1 and the pressure in this phase will be greater than in fluid P_1.

The above considerations have shown, then that there are equilibrium positions within the theoretical pore of Fig. 1 for which the pressure in one fluid phase may be greater than, equal to, or less than the pressure in the other fluid phase although the wetting properties and contact angle are everywhere the same.

From geometrical considerations, it can be shown[4] that for the pore under discussion,

$$\frac{P_c R}{2\sigma} = \frac{\text{Cos } (\theta - \alpha)}{1 + R/r\ (1 - \text{Cos } \alpha)} \quad \ddagger$$

where P_c (the capillary pressure) is the pressure difference between the two fluids, P_1 and P_2, σ is the interfacial tension, R the radius of curvature of the solid, r the minimum radius of the pore and θ and α are angles as defined above. Fig. 2 shows the dimensionless quantity $\frac{P_c r}{2\sigma}$ plotted as a function of α for various values of contact angle, θ, as measured through fluid P_1 and for an arbitrary R/r spacing of 4. From this plot it is seen that for a given contact angle (0° and 180° excepted), the capillary pressure, P_c, exhibits both positive and negative values for positions of the interface within the pore, since r and σ are always positive. Positive values of P_c indicate that the pressure in fluid P_2 is greater than that in P_1; negative values indicate the converse situation.

We consider now the capillary behavior in a three dimensional array of pores similar to that shown in Fig. 1. The pore spaces are originally filled with water (P_1) which is to be displaced with oil (P_2) by the standard porous plate capillary pressure technique. Let us say the solid is preferentially water wet and that the contact angle of oil and water against the solid

†In this discussion, the effect of gravity on the shape of the interface is considered to be negligible.

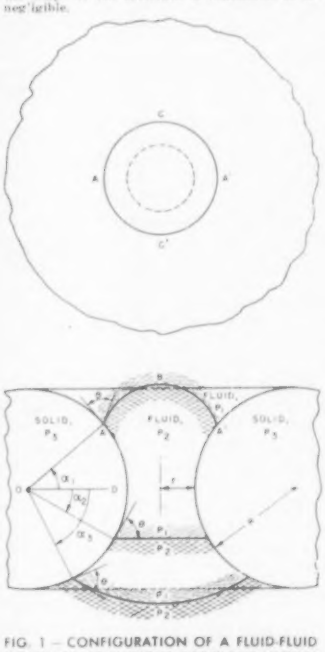

FIG. 1 — CONFIGURATION OF A FLUID-FLUID INTERFACE AT VARIOUS POSITIONS WITHIN A "DOUGHNUT-SHAPED" PORE.

*For the treatment of a similar pore in a study of textiles, see References 3 and 4.

‡Compare this equation with that for a capillary tube, $\frac{P_c r'}{2\sigma} = \text{Cos } \theta$, where r' is the internal radius of the tube.

is 30° as measured through the water phase. As oil is brought into contact with the water saturated specimen, the pressure in the two liquid phases being the same, there will a slight spontaneous displacement of the water until the oil-water interface reaches a position described by $\alpha = -60°$ (Point *A*, Fig. 2) in the pores exposed at the surface. If the number of surface pores is small, compared to the total number of pores, the volume of water displaced, in terms of total pore space, will be relatively small. This initial displacement is represented by a portion, *A-B*, of a hypothetical capillary pressure curve shown in Fig. 3. Pressure in excess of that of the water phase is now applied gradually to the oil resulting in a further small displacement of water corresponding to movement of the interface in the surface pores from $\alpha = -60°$ to $\alpha = +7°$ (Point *B*, Fig. 2) and represented by the line *B-C* of the capillary pressure curve. At point *B* a sufficiently high pressure differential, corresponding to a value of $\frac{P_c r}{2\sigma} = 0.9$, is reached to cause most of the water, including that in the interior pores, to be displaced (*C-D*, Fig. 3), since this value represents the maximum stable capillary pressure that can be realized in any of the pores. Some water may be trapped in corners of the pores because of bridging of the oil-water interface as it moves from one pore to the next in the displacement of water from the interior pores and this results in an irreducible minimum as shown in Fig. 3.

If the pressure difference between the oil and water is now reduced to zero a slight amount of oil may be displaced by imbibition of water in the surface pores as from *D* to *F* in Fig. 3. The bulk of oil will be displaced, however, only if the pressure in the water is made greater than that in the oil. All of the oil, except that trapped by bridging, will be displaced when the pressure excess in the water phase corresponds to a value of $\frac{P_c r}{2\sigma} = -0.1$ (*G* to *H*, Fig. 3; point *C*, Fig. 2).

If one adopts the capillary tube model, then it may be necessary to postulate that Welge's experiments showed lack of equilibrium conditions, as suggested by Rose. It is possible, however, to assume that the experiments were carried out under equilibrium conditions and explain the results on the basis of the pore geometry illustrated by Fig. 1. It is believed that the pore herein considered may be more nearly descriptive than the capillary tube of the pores actually existing in reservoir rocks.

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1. Walter Rose. "A Note on the Application of the Capillary Pressure Method for the Determination of Oil Recovery," *Petr. Tech.*, Section 1, p. 30, (March, 1949).
2. H. J. Welge. "Displacement of Oil from Porous Media by Water or Gas," AIME *Trans.*, Vol. 179 (1948).
3. A. B. D. Cassie and S. Baxter. "Wettability of Porous Surfaces," *Trans. of the Faraday Soc.*, **40**, 546 (1944).
4. A. B. D. Cassie. "Permeability to Water and Water Vapor of Textiles and Other Fibrous Materials," *Discussions of the Faraday Society*, No. 3, p. 239, (1948).
5. D. J. Crisp and W. H Thorpe. "The Water-Protecting Properties of Insect Hairs," *Ibid.*, p. 210. ★ ★ ★

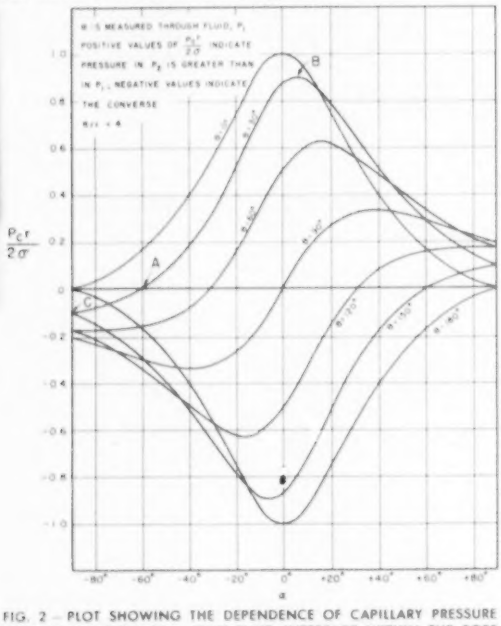


FIG. 2 — PLOT SHOWING THE DEPENDENCE OF CAPILLARY PRESSURE ON THE POSITION OF A FLUID-FLUID INTERFACE WITHIN THE PORE OF FIG. 1

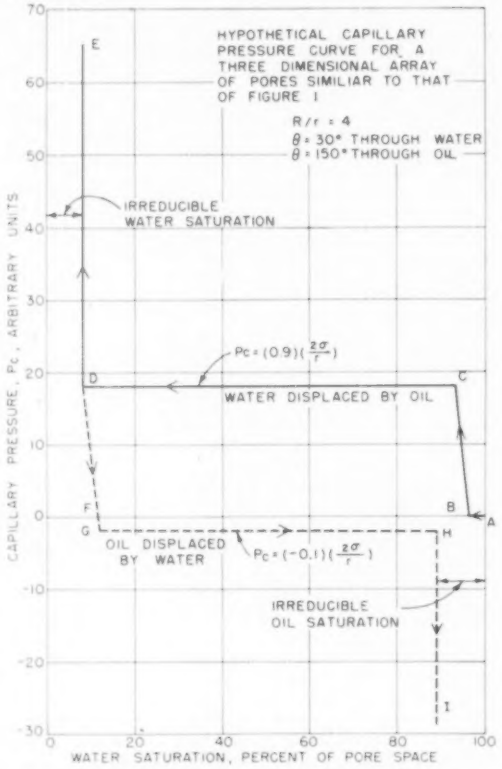


FIG. 3 — HYPOTHETICAL CAPILLARY PRESSURE CURVE FOR A THREE DIMENSIONAL ARRAY OF PORES SIMILAR TO THAT OF FIG. 1.

Legal Aspects of Unitization

By Milan G. Arthur

Speaking last month before some 70 members and guests of the Pacific Petroleum Chapter in Los Angeles, Mortimer Kline, a lawyer with extensive experience in the petroleum industry said that an intelligent discussion must be preceded by an understanding of the meaning of unitization, the objects and advantages to be accomplished by unitization, the necessity of unitization to accomplish such objectives and the forms of unitization plans.

Kline was speaking about the legal aspects of unitization. Development of petroleum resources has expanded at an amazing rate and the success of the petroleum industry is due in large measure to the existence of competitive enterprise. Although petroleum reserves are vast, it is recognized that these reserves are limited. Because of the limited reserves of this irreplacable natural resource, there has developed improvement in production practices and enactment of statutes to permit operation of oil fields under improved methods of depletion. In California, conservation has existed on a voluntary basis.

In the initial stages of development of the petroleum industry, the adjustment of property rights to oil and gas were established by "rule of capture." giving a property owner title to all oil and gas produed through wells located on his land, regardless of the underground source. As a result of the obligations of lessees operating under the "rule of capture," much waste of petroleum has occurred and many more wells have been drilled than the number necessary to recover the hydrocarbons. There has existed a practice of destructive self-preservation. Kline referred to Robert Hardwicke's article, "The Rule of Capture and Its Implications as Applied to Oil and Gas," 13 Texas Law Review 391. The excessive drilling and the duplication of surface facilities have resulted in the development of pooling, spacing regulations and unitization. It is generally recognized that only a minor fraction of the oil occurring underground is recovered by older production techniques. The recovery could sometimes be doubled by newer techniques which can be applied under unitized operation. Unitization is not an end in itself, but merely a tool which will permit the best operation of the field.

Frequent limitation of the term unitization to so-called secondary methods of recovery is unfortunate, since the beneficial results are obtainable if the reservoir is unitized during the initial stages of depletion. Kline defined the differences between unit projects, cooperative projects, and pooling by quoting the definitions adopted by a Committee of the Interstate Oil Compact Commission. While the desirability of unitized operation is evident, the ownership of lands by many persons within a single pool, each privileged to drill and produce oil or gas, makes unit operation of the entire pool impossible unless by voluntary agreement or by legislative compulsion those interests can be merged or unitized. It is Kline's opinion that proper education is the most successful approach to the problem of accomplishing unitization. The benefits to be accomplished by unitization are proved by past performance and include minimized capital investment, minimized operating cost, increased recovery of petroleum, and stabilization of the industry.

Preparation of the plan of unitization requires a tremendous amount of effort. There is no standard form of unit agreement and each agreement must be designed to fit the particular situation. Operations are generally assigned to one operator with supervisory power vested in a majority of the participants. An important feature of the unit plan is the method of financing operations. This is almost universally accomplished by payment of operating costs in the first instance by the unit operator and by billing each of the unit lessees for their proportionate shares thereof. The operator is given a lien upon the interest of the non-operators to insure payment of these advances. The basis for allocation of unitized substances among participants varies. In some cases allocation is based on surface acres only, in other cases on the basis of recoverable oil or acre-feet of sand. Another important provision on the agreement relates to extension of the participation area as additional tracts outside of the initial unit boundary are proved to be productive. Another important feature is that of relative participation which may be either fixed at the outset or subject to adjustment by some acceptable formula. Kline recommended a paper dealing with the negotiation and preparation of unitization agreements written by R. M. Williams of Bartlesville, Okla., and published in the first annual report of the Southwestern Legal Foundation Institute on Oil and Gas Laws.

The royalty owner's consent can be most satisfactorily secured by education of the royalty owner. The lessors should be thoroughly advised of the objectives by the lessees and unitization will be consummated more efficiently if the lessors employ the advice of a reputable, independent consultant. Although a sound project works to the advantage of the royalty owner, there are some situations wherein the royalty owner cannot be personally contated or where the royalty owner is recalcitrant or dilatory in response. An adequate remedy to this complication is afforded in the laws of Oklahoma and Louisiana, in particular, wherein it is provided that subsequent to notification and opportunity to respond, the commissions established in these states have authority to make a fair and reasonable program binding upon royalty owners who have not agreed to the program. It was pointed out that one man experienced in unit negotiations said, "Strange as it may seem, these (headaches) for the most part include not the legal consideration of royalty owners, nor as much recalcitrant operators, as they do problems involving the selfish interests as between operators who profess a willingness to unitize, but who try the souls of men with a persistent failure to get down to business, or a refusal to agree upon matters that are relatively minor in relation to the benefits to be derived by conceding a point here and there and speeding the day of unitization."

In the absence of statutes, the royalty owner who refuses to assent to a proposal for unit operation is under no legal compulsion to do so. Under exist-

Continued on Page 3, Section 2

RICHARD V. HUGHES
Calls for More Cooperation

PACIFIC TECHNOLOGY GROUP

Water Flood Research

By Milan G. Arthur

The third lecture of the AIME series on secondary recovery was given by Richard V. Hughes of the Stanford Research Institute June 26, at the General Petroleum Auditorium in Los Angeles. Hughes discussed water flooding research and its application to field problems.

Hughes expressed the opinion that it is fortunate that water flooding was initially developed in the Bradford field of Pennsylvania. The Bradford field had undergone two periods of primary drilling and had failed to respond satisfactorily to vacuum and air-gas drive. Water-flooding practice started with accidental floods and operating techniques progressed continuously. In spite of some opinion to the contrary, the Bradford field presents some rather unfavorable sand conditions. The permeability is very low and the sand is complicated by extreme lenticularity and by structural anomalies. It is apparent that water flooding has been a financial success in the Bradford field largely because of the premium value of its crude oil.

Research and development of technology were recognized at an early stage of water flooding development and Pennsylvania producers sponsored and financed much of this research. Despite the expenditures on research, most water flood development and operating procedures are based on "rule-of-thumb" methods. Generally, laboratory research in water flooding is years behind field practice. Many water flood operators believe that there is too much emphasis at the present time on fundamental research. The progressive operator does not condemn fundamental research, but he believes that much of it has been started too late, that it misses the real problem by dealing with idealized conditions, and that it progresses too slowly to assist him. Both operators and research workers have sometimes made the mistake in believing that all research work can be applied directly to field problems.

One of the basic causes of the operators' lack of appreciation of research results from the frequent disagreement among research workers over methods and conclusions, and the lack of field experience on the part of research workers. Hughes discussed in detail some of the more prominent items of disagreement. One of these controversial issues is the relationship of oil recovery to the magnitude of pressure gradients employed in expelling the oil with water. Numerous papers were cited that give conflicting interpretations and conclusions. Another topic of disagreement is the evaluation of applicability of water flooding to certain sands. Here, too, much conflicting material has been published, some of which is diametrically opposed to field experience.

Other controversial matters include the value of capillary pressure measurements for interstitial water content, whether or not sands are oil wet or water wet, the relative merits of high and low *pH* fresh waters and brines, the residual oil saturations obtained in the field, maximum safe sand-face pressures, the relative merits of flowing or pumping production, whether or not an oil bank forms ahead of the flood and, if so, is it desirable, the affects of high oil viscosities upon recoveries, and the possibility of utilizing surface active agents.

Such a condition of disagreement on research results is partially the fault of those who finance and those who perform the research, Hughes declared. The research worker should realize that no synthetic core material can be utilized as a substitute for an actual sand in applied research, nor can sweeping conclusions be drawn from the utilization of core material from one or even several actual oil sands. With respect to the problems of pressure gradients and recovery, it must be realized that non-uniformity of reservoir sands influ-

Continued on Page 3, Section 2

A BREAK IN THE MEETING brought these three members together for a private discussion on secondary recovery problems at the Pacific Coast Petroleum Technology Group's third lecture of a summer series. They are, left to right, C. R. Dodson, University of Southern California professor; Branch Chairman John E. Sherborne, Union Oil Co.; and Carrol M. Beeson, associate professor at USC.

Sub-Surface Instruments

By W. G. Paul, Jr.

W. C. Sheldon, reservoir engineer with the Ohio Oil Co. in the San Joaquin Valley, discussed the uses of subsurface instruments in reservoir engineering at a meeting last month of the Junior Section of the Pacific Petroleum Chapter in Downey, Calif.

Sheldon emphasized the many problems confronting the reservoir engineer. In his analysis the engineer must rely upon well data, which in the most highly developed fields represents relatively few and poor sample points. Also, the data must be interpreted to properly develop intrinsic reservoir properties. Such factors as completion effectiveness and producing conditions imposed will cloud the picture. Sheldon coined the term "well effectiveness," the ratio of what the well is doing to what it should do, to describe the major clouding factors in producing well analysis.

Once these factors are properly isolated, those which make up intrinsic reservoir properties are equally difficult to evaluate. Reservoir size, zone thickness, lithologic properties, depth and pressure, composition, saturation, permeability and its distribution, should all be considered in a proper analysis.

With a new well there is often available core information and electric log analysis, but in later years this information may not answer pressing reservoir questions. It then becomes necessary to apply other survey tools to determine what has happened within the reservoir since the well was drilled.

Possibly the most common subsurface analysis tool is the thermometer or temperature recorder. Its purpose is to record temperatures at various points in the well bore under various conditions, static or producing. The most familiar is the maximum-minimum recording thermometer which can be run in various ways but which will provide only the maximum temperature encountered. The bi-metallic thermometer when operating a stylus on a clock-driven chart will improve the data by giving a continuous reading which can be correlated with positions in the well bore. One problem, however, is that accurate data requires an equilibrium condition for each temperature measurement. As it cannot be determined at the surface when the unit has reached equilibrium in the well bore this necessitates a considerable time lag in the measuring process, and will often limit the number of valid measurements that can be economically taken.

Several relatively new units operated on "shooter's lines" or "piano wire" are available to overcome this problem. One such unit photographs the displacement of a bi-metallic temperature element. With the film passing the element at a set rate of speed and with the unit also traveling in the hole at a constant rate, the developed film will show the temperature at any point in the well bore covered during the run. Travel speed of the instrument can be controlled to insure accuracy of measurement.

A second unit can be operated to provide a surface reading at the time the temperature is being measured down the hole. Changes in tension of a wire vibrating within a magnetic field in the instrument are created by the temperature. The frequency changes thus created are transmitted to the surface and, through a comparator unit, converted to temperature readings. This same unit can be adapted to record pressure and flow measurements at the surface on the same run.

In evaluating the results of temperature surveys it is essential to first have a stabilized shut-in gradient. A comparison of this gradient with a flowing gradient reveals the anomalies which are used in the interpretation of reservoir conditions. Sheldon emphasized the importance of these anomalies and the relative unimportance from a practical standpoint of the absolute temperature value. The principle anomaly which is sought is that which indicates a point of gas entry. Proper analysis and comparison will indicate where the greatest volume and pressure differences exist. Sheldon cited the case of one Valley operator, measuring temperatures to one hundredth of a degree, who performed 21 remedial jobs on the basis of temperature surveys; all of which were successful in correcting high gas oil ratios.

W. C. SHELDON
"Engineers Rely on Well Data"

Equally as common as the temperature instruments are the pressure recorders. Sheldon mentioned briefly the Humble and Amerada units with which most operators are familiar. A more recent development is the tool discussed with temperature instruments which measures pressure through the same vibrating wire, frequency change principle. Accuracy as high as one lb in 6,000 lb or measurements to one ft of elevation are claimed for this tool.

Spinner surveys are possibly the next most important analysis method. All units involve the use of a propellor, the speed of rotation at any set position in the well bore being a measurement of the rate of fluid movement past the unit. One tool records this measurement on film, self-contained within the instrument. Two other units convert the propellor rotation to electrical units through a commutator-amplifier arrangement and record at the surface.

The value of a spinner survey is in pinpointing the productive intervals of the well. Also, on a shut-in survey, it is of considerable assistance in locating thief zones and interzone migration. Where surveys are available from time to time over the productive life of a well, it is possible to determine which production intervals are dropping off and which are the major contributors to the well production. A comparison of spinner and temperature surveys will serve to qualify the character of fluid movement. Sheldon emphasized the importance of these surveys where wells are to be used as injection wells for pressure maintenance and water flooding.

Some of the problems with spinner

Continued on Page 6, Section 2

SHALE
SHALE
SHALE

DISCUSSION OF THIS AND ALL FOLLOWING TECHNICAL PAPERS IS INVITED
Discussion in writing (3 copies) may be sent to the Editor, *Journal of Petroleum Technology*, 601 Continental Building, Dallas 1, Texas, and will be considered for publication in the Transactions volume *Petroleum Development and Technology*. Discussion will close December 1, 1950. Any discussion offered thereafter should be in the form of a new paper.

LIQUID-LIQUID DISPLACEMENT IN POROUS MEDIA AS AFFECTED BY THE LIQUID-LIQUID VISCOSITY RATIO AND LIQUID-LIQUID MISCIBILITY

J. P. EVERETT, MEMBER AIME, OKLAHOMA A&M COLLEGE, STILLWATER, OKLAHOMA, **F. W. GOOCH, JR.,** U. S. NAVY, AND **JOHN C. CALHOUN, JR.,** MEMBER AIME, UNIVERSITY OF OKLAHOMA, NORMAN, OKLAHOMA

SUMMARY

The results of two sets of displacement experiments are reported. In the first set of experiments various solutions of sugar in water were displaced by other solutions of sugar in water. In the second set oils were displaced by water. Each set of experiments was performed on a linear system made of cemented silica sand grains.

These displacement tests were made to evaluate the behavior when the ratio of fluid viscosities between the displacing and displaced phases was varied. A further consequence of the test results is a comparison between displacement behavior when the displaced and displacing phases are miscible as with sugar solutions and when they are immiscible as with oil and water.

INTRODUCTION

Buckley and Leverett[1] have presented a theory for the displacement of oil by gas or water based upon the relative permeability concept. This theory presents the displacement of oil as occurring in two phases, an initial or primary phase preceding the breakthrough of the displacing phase and a subordinate or secondary phase during which both oil and the displacing phase flow simultaneously through the same porous section. These authors gave the results of calculations to show that the percentage of oil displaced during the primary phase by water drive would be dependent upon the ratio of the viscosity of the oil to that of the water. No experimental evidence was reported by these authors to substantiate their theory. Qualitatively, however, it has been found to be in agreement with many observed field results.

Laboratory investigators have been in general agreement in reporting for air or gas drive[2,3] a small primary phase of production and a large secondary phase. Reported investigations on water drive[4,5,6] have shown instances where both primary

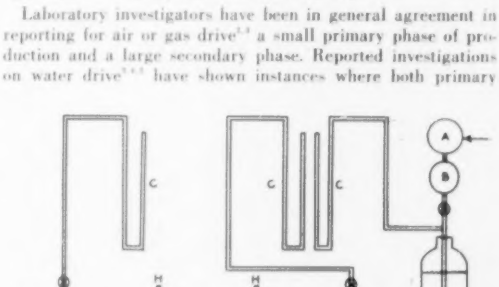


FIG. 1 — SCHEMATIC FLOW ARRANGEMENT FOR DISPLACEMENT OF SUGAR SOLUTIONS BY WATER. A, B — PRESSURE REGULATOR; C — MERCURY MANOMETERS; D — GLASS FLUID RESERVOIR; E — VALVE FOR CLEANING FLUID SYSTEM; F — POROUS SECTION OF SAND; G — OUTLET CONTROL VALVE; H — PRESSURE CONNECTIONS; I — GRADUATED CYLINDER; J — FILTER.

[1] References are given at the end of the paper.

Manuscript received at the office of the Petroleum Branch October 1, 1949. Paper presented at the Petroleum Branch meeting in San Antonio, October 5-7, 1949.

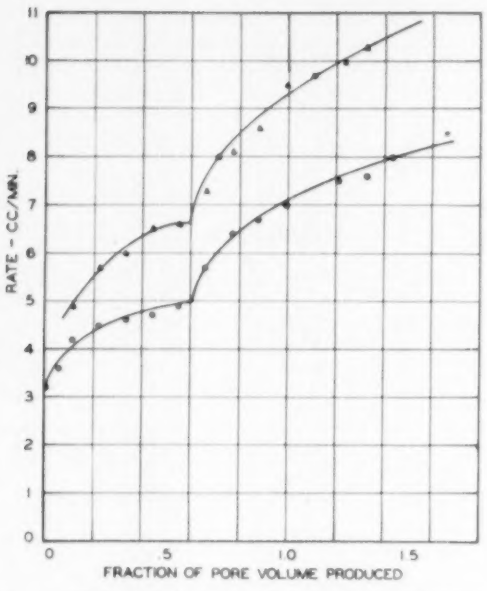


FIG. 2 — INCREASE OF PRODUCTION RATES DURING DISPLACEMENT. VISCOSITY RATIO (DISPLACED OVER DISPLACING FLUID) IS 4.25; PRESSURE IMPOSED IS 220 mmHg. △ HORIZONTAL RUN. ○ VERTICAL RUN DOWNWARD.

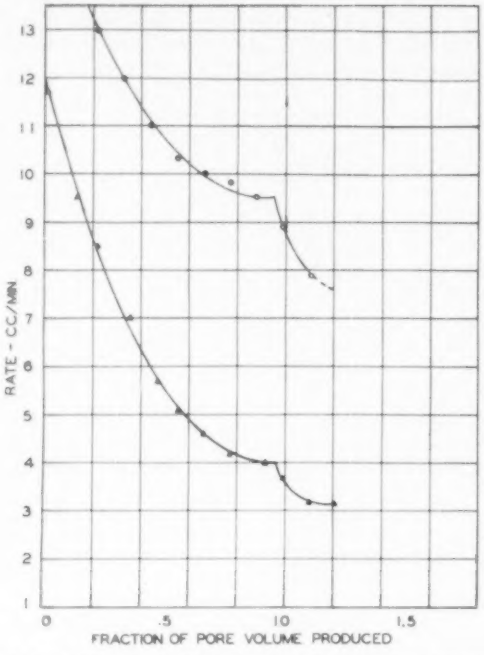


FIG. 3 — DECREASE OF PRODUCTION RATES DURING DISPLACEMENT. △ — VISCOSITY RATIO (DISPLACED OVER DISPLACING FLUID) IS 0.235; PRESSURE IMPOSED IS 220 mmHg. VERTICAL RUN UPWARD. O — VISCOSITY RATIO (DISPLACED OVER DISPLACING FLUID) IS 0.874; PRESSURE IMPOSED IS 220 mmHg. HORIZONTAL RUN.

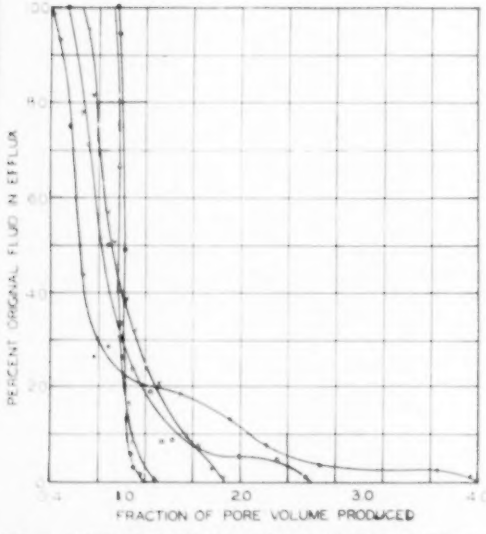


FIG. 4 — EFFLUX COMPOSITIONS VERSUS CUMULATIVE IN PORE VOLUMES (HORIZONTAL RUNS). VISCOSITY RATIO (DISPLACED OVER DISPLACING FLUID) X = 9.1; O = 4.25; V = 2.34; △ = 1.14; ○ = 0.437.

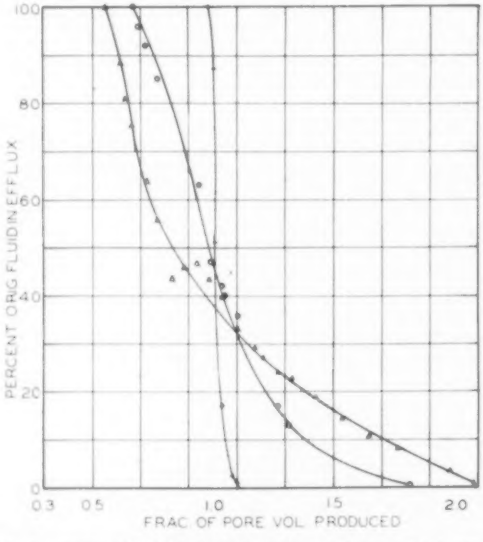


FIG. 5 — EFFLUX COMPOSITION VERSUS CUMULATIVE IN PORE VOLUMES (VERTICAL RUNS). VISCOSITY RATIO (DISPLACED OVER DISPLACING FLUID) △ = 4.25; O = 2.29; X = 0.235.

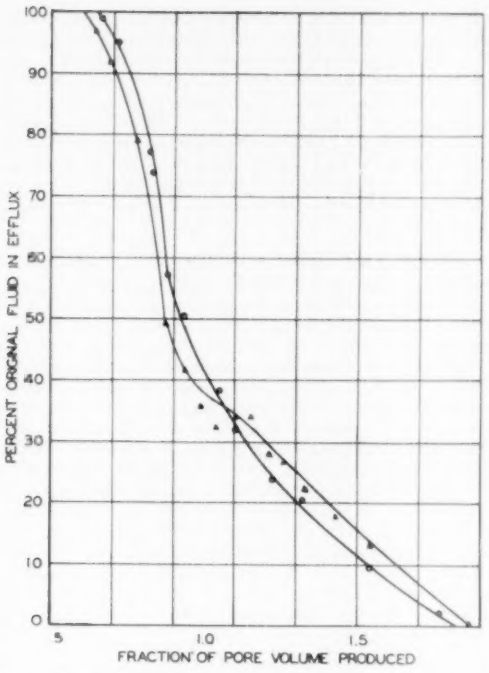


FIG. 6 – DISPLACEMENT AT TWO PRESSURE GRADIENTS (HORIZONTAL RUNS) VISCOSITY RATIO (DISPLACED OVER DISPLACING FLUID) IS 2.35. O = IMPOSED PRESSURE IS 220 mmHg. △ = IMPOSED PRESSURE IS 760 mmHg.

and subordinate phases were important, with the former in general being more significant.

Other investigators have presented data on other types of displacement. Data on the mobility of connate water was presented[7] with the conclusion that displacement efficiency would be high. One of the present authors in a former work[4] noted but did not report comprehensive data on the removal of connate water by a fresh water drive. These data also supported the belief that connate water would be displaced effectively from a porous material by invading water.

Huntington and others[5,6] have given data on the displacement of one gas by another and on the displacement of carbon tetrachloride by hexane from a column of unconsolidated sand. These experiments indicated the occurrence of displacement in primary and secondary phases, even for the displacement of one gas by another. Their data is presented in terms of mixing rather than in terms of displacement efficiency. The data reported for hexane-carbon tetrachloride displacement indicated a variation in displacement efficiency during the primary phase as the speed of displacement varied. For gas-gas displacement these investigators found a variation in efficiency with the pressure of the gas system.

The literature also contains reference to displacement in ideal capillary systems and in pipe lines,[8] which situations may not be directly applicable to petroleum production but they nevertheless provide a basis for analyzing results of displacement from porous media.

The present work was undertaken in an effort to supply data which it was hoped might be added to that cited to form support for a comprehensive displacement theory. In particular, it was felt that Buckley and Leverett's[1] analysis pointed to the viscosity ratio between displaced and displacing fluids as an important variable. A perusal of other cited references led to the thought that the displacement from a porous medium of one fluid by another miscible with it would be in many

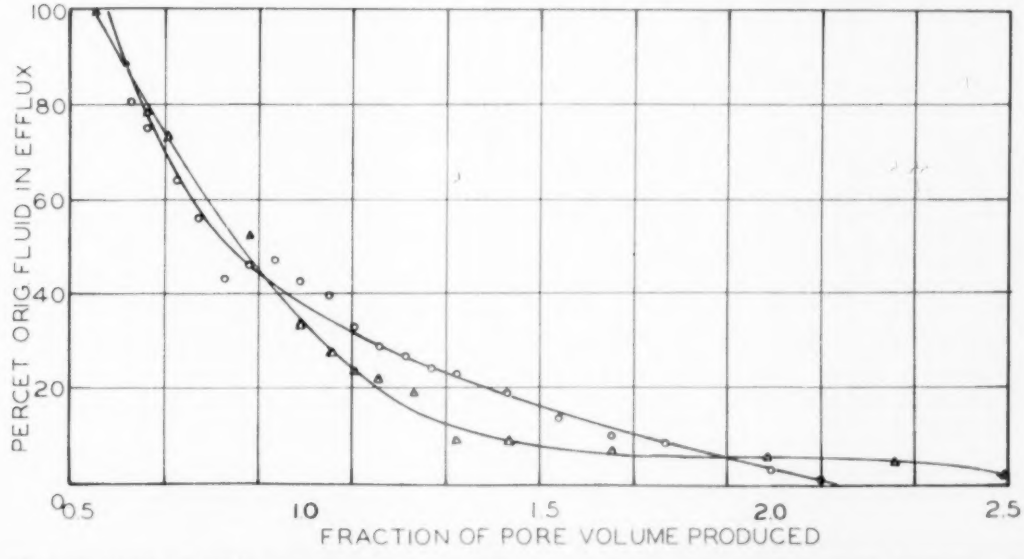


FIG. 7 – COMPARISON OF VERTICAL AND HORIZONTAL RUNS. VISCOSITY RATIO (DISPLACED OVER DISPLACING FLUID) IS 4.25; PRESSURE IMPOSED IS 220 mmHg. O = VERTICAL RUN. △ = HORIZONTAL RUN.

respects similar to the displacement of a fluid by one immiscible with it. It was anticipated that observation of such comparison might lead to a simpler basis for a theoretical approach to displacement calculations.

The experimental work reported in the following sections was carried out as two different problems on similar sand systems. Some of the details of experimental technique differ therefore. The problems were approached in similar fashions and are hence reported here together.

DISPLACEMENT OF A LIQUID BY ANOTHER WITH WHICH IT IS MISCIBLE

This portion of the work was performed on a sand column, 93.7 cm in length and 6.35 cm inside diameter. An unconsolidated sand, cleaned and fired, of 80-140 mesh was packed by vibration into a lucite tube filled with a colloidal suspension of silica. After the tube was filled with sand and liquid, the excess silica suspension was displaced by air. The sand filled tube was then dried by passage of hot air and evacuation. The resulting sand system was, therefore, lightly consolidated. The resulting system had a pore volume of 907 ccs and an average porosity of 30.7 per cent as found by water saturation. The permeabilities to air of the three sections shown in Fig. 1 were 3.81, 4.01, and 3.82 darcies.

Fig. 1 is a schematic drawing of the manner in which this porous sand section was set up for displacement tests. The liquids used were water and solutions of sucrose in water. By varying the amounts of sucrose in solution the viscosities were varied.

Displacement was measured in terms of the concentration of sucrose in the effluent. This was determined by measurement of refractive index. The effluent was collected in increments which varied from 50 to several hundred ccs. The porous system was cleared of its liquid after a given run and prepared for a new run by the continued flowing of the liquid which was to be the new saturant.

Runs were made with the sand system in both the vertical and horizontal positions. Vertical runs were made because it was noted that a slight gravitational settling was occurring on the horizontal runs. During vertical runs the displacing liquid was injected at the bottom when it was heavier than the displaced liquid and from the top when it was the lighter of the two. All runs were made with a constant pressure differential imposed across the two ends of the system. This resulted in a variation of displacement velocity during the course of a given displacement test.

The results of these displacement tests are shown in graphical form in Figs. 2 to 10. Table I gives a summary of information on these runs. In this table μ_o denotes the viscosity of the displaced phase and μ_w the viscosity of the displacing phase. On all runs except 1 and 6 sugar solutions were displaced by water. On runs 1 and 6 water was displaced by sugar solution.

DISPLACEMENT OF OILS BY WATER

The second group of experiments were performed on a column of sand similar to that described in the previous section. Unconsolidated sand between 65 and 270 mesh was the starting material. This was partially consolidated by packing it in a suspension of colloidal silica. Further consolidation was performed by saturating the column with an alcoholic solution of tetraethyl orthosilicate, displacing as much of this liquid as was possible by air and hydrolizing the remainder. Several repetitions of this cementing procedure were used. Finally, one end of the core system was cut off and discarded because the cementing material had built up excessively due to concentration of the cementing liquid by capillary forces.

Pressure taps were placed along the sand column and the air permeabilities of the various linear portions were measured as 2.77, 2.44, 2.54, and 2.99 darcies. The average porosity of the system was found to be 27.2 per cent with a total pore volume of 980 ccs. The overall column was 115.8 cm long and 6.35 cm inside diameter.

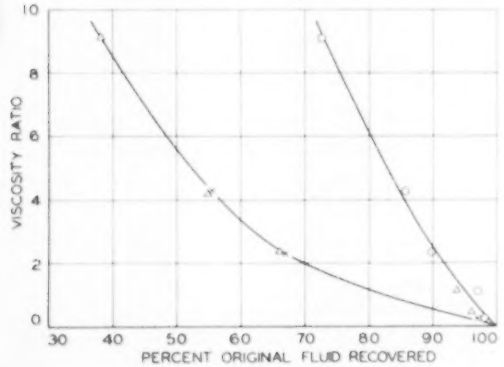


FIG. 8 — PER CENT OF ORIGINAL FLUID RECOVERED AS A FUNCTION OF VISCOSITY RATIO. △ — AT BREAKTHROUGH (HORIZONTAL RUNS). X — AT BREAKTHROUGH (VERTICAL RUNS). ○ — AT ONE PORE VOLUME CUMULATIVE.

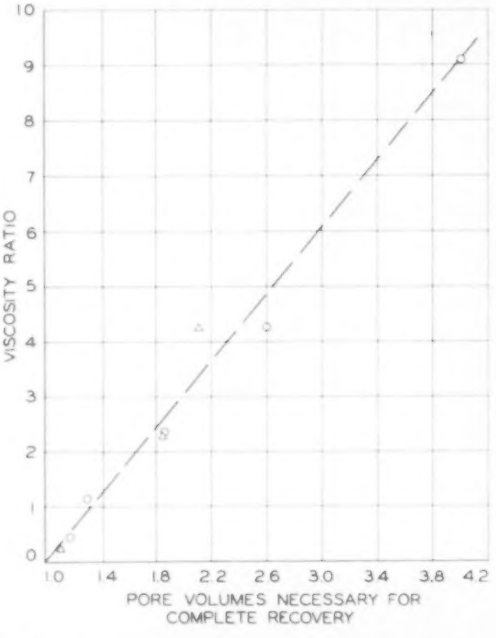


FIG. 9 — CUMULATIVE NECESSARY TO COMPLETE DISPLACEMENT (WATER-SUGAR SOLUTION DISPLACEMENTS). 0 — HORIZONTAL RUNS. ○ — VERTICAL RUNS.

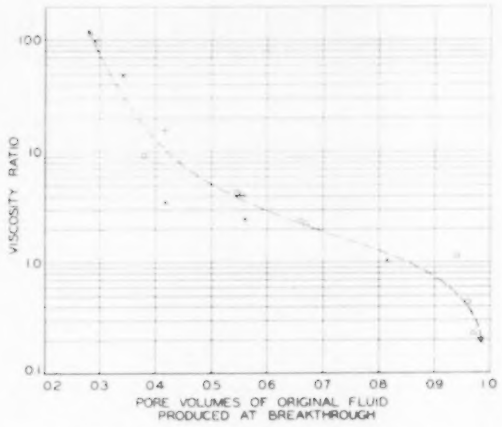
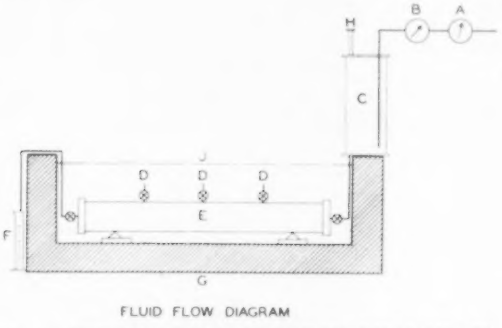


FIG. 10 — PORE VOLUMES PRODUCED AT BREAKTHROUGH OF DISPLACING LIQUID AS A FUNCTION OF VISCOSITY RATIO. O — WATER-SUGAR SOLUTION DISPLACEMENT (HORIZONTAL RUNS). △ — WATER-SUGAR SOLUTION DISPLACEMENT (VERTICAL RUNS). X — WATER-OIL DISPLACEMENT.



FLUID FLOW DIAGRAM

FIG. 11 — SCHEMATIC FLOW ARRANGEMENT FOR DISPLACEMENT OF OIL BY WATER. A, B — PRESSURE REGULATORS, C — METAL FLUID RESERVOIR, D — PRESSURE CONNECTIONS, E — POROUS SAND SECTION, F — GRADUATED CYLINDER, G — WATER BATH, J — WATER LEVEL IN BATH.

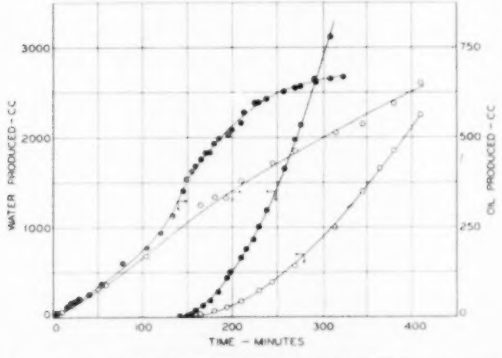


FIG. 12 — OIL AND WATER PRODUCTION AS A FUNCTION OF TIME. O — OIL-WATER VISCOSITY RATIO IS 98.6. ● — OIL-WATER VISCOSITY RATIO IS 48.53. PRESSURE IMPOSED IS 20 PSIG.

Fig. 11 gives a diagrammatic sketch of the flow set up. Runs were made with the core always in a horizontal position and with the assembly placed in a water bath so that the viscosities of the liquids could be controlled to desired values. A constant pressure differential was imposed for the duration of each run and rates were permitted to vary. Pressure was imposed by applying nitrogen to a reservoir chamber containing the displacing liquid as shown in Fig. 11.

The oils were standard grade lubricating oils, kerosene, deodorized naphthas, and blends of lubricating oils with naphthas. By varying the type oil and the temperature during displacement the desired ratios of oil viscosity to water viscosity were obtained. The displacing liquid was always water.

The results of the water-oil displacement experiments are shown in Figs. 12 to 20 and in Fig. 10. Table II gives a summary of conditions and numerical results on these displacements.

DISCUSSION OF EXPERIMENTAL RESULTS

An examination of the results of both sets of experiments will show that displacement always occurred in two phases — the primary phase prior to breakthrough of the displacing liquid and the secondary phase from breakthrough until cessation of production. Figs. 4, 5, 15, 16 and 17 show point of breakthrough and per cent of original fluid in the efflux as a function of the total pore volumes of fluid produced. The point of breakthrough always was followed by a sharp drop in the amount of displaced fluid in the efflux.

In both sets of experiments the relative importance of the primary and secondary phases varied with the fluid viscosities.

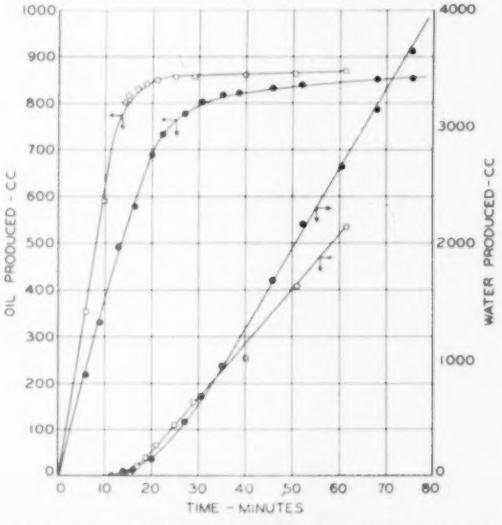


FIG. 13 — OIL AND WATER PRODUCTION AS A FUNCTION OF TIME. O — OIL-WATER VISCOSITY RATIO IS 1.04. ● — OIL WATER VISCOSITY RATIO IS 3.51. PRESSURE IMPOSED IS 20 PSIG.

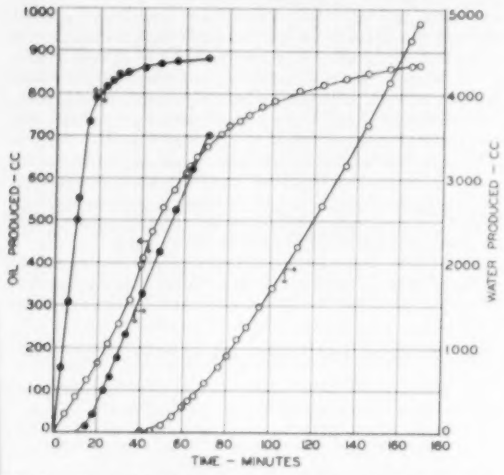


FIG. 14 — OIL AND WATER PRODUCTION AS A FUNCTION OF TIME. O — OIL-WATER VISCOSITY RATIO IS 15.49. ● — OIL-WATER VISCOSITY RATIO IS 2.41. PRESSURE IMPOSED IS 20 PSIG.

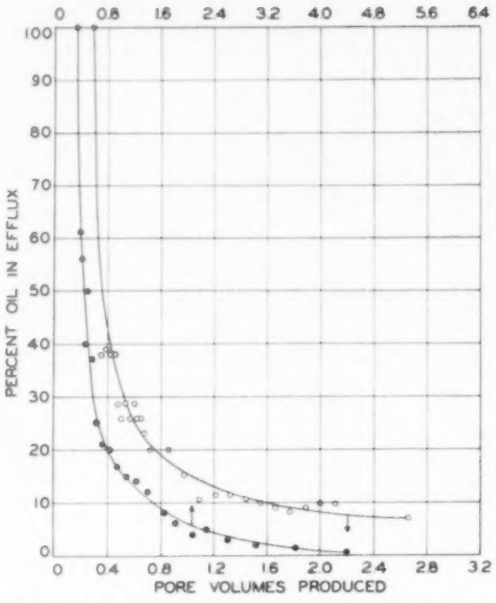


FIG. 15 — PER CENT OIL IN EFFLUX VERSUS TOTAL CUMULATIVE PRODUCTION. O — OIL-WATER VISCOSITY RATIO IS 98.6. ● — OIL-WATER VISCOSITY RATIO IS 48.53. PRESSURE IMPOSED IS 20 PSIG.

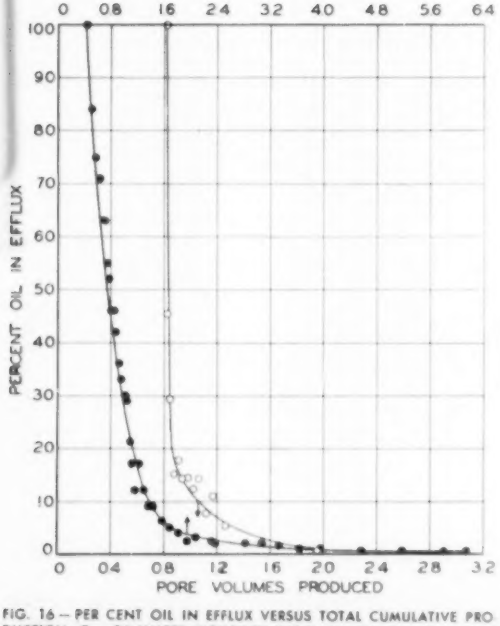


FIG. 16 — PER CENT OIL IN EFFLUX VERSUS TOTAL CUMULATIVE PRODUCTION. O — OIL-WATER VISCOSITY RATIO IS 1.04. ● — OIL-WATER VISCOSITY RATIO IS 3.51. PRESSURE IMPOSED IS 20 PSIG.

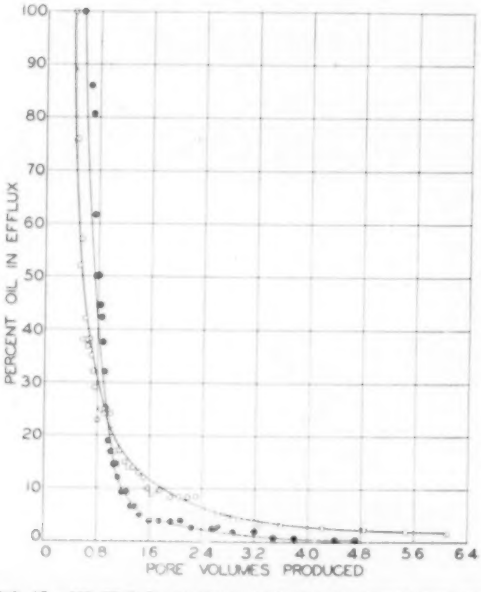


FIG. 17 — PER CENT OIL IN EFFLUX VERSUS TOTAL CUMULATIVE PRODUCTION. O — OIL-WATER VISCOSITY RATIO IS 15.49. ● — OIL-WATER VISCOSITY RATIO IS 2.41. PRESSURE IMPOSED IS 20 PSIG.

Following the lead of Buckley and Leverett[1] this variable has been expressed as the viscosity of the displaced liquid divided by the viscosity of the displacing liquid.

Fig. 8 indicates the effect of the viscosity ratio upon the recovery at breakthrough and at one pore volume cumulative for the water-sugar solution displacements. Fig. 9 is a plot of the cumulative throughput necessary to effect complete recovery on these same displacements.

The primary phase displacement was very close to 100 per cent for low viscosity ratios. The theoretical limit for this type displacement would be 100 per cent recovery in the primary phase at a viscosity ratio of zero. This is shown on both Figs. 8 and 9.

Fig. 18 gives the effect of viscosity ratio for the water-oil displacements. Here also the primary phase yields higher recoveries for lower viscosity ratios. The apparent upper limit for displacement during the primary phase is 91 per cent at a viscosity ratio of zero. Fig. 18 indicates that all water-oil displacements might ultimately have reached this recovery had they been carried to a sufficiently high water-oil ratio. All these runs were terminated before an ultimate point was reached. Table II gives total recovery at cessation of displacement.

In these experiments a pressure differential for carrying on the displacement was arbitrarily assigned. No particular attention was paid to rates of displacement except to note that the displacement speeded up or slowed down depending on whether the displacing liquid had the lower or higher viscosity. Figs. 2 and 3 show typical rate data recorded for the water-sugar solution displacements. It is to be noted in these figures that the rates for the horizontal and vertical runs differ because the imposed pressure differential on the vertical runs was not corrected for the gravitational head.

Fig. 6 gives the results on a pair of runs made at two pressure differentials. At the higher differential, which would also mean the higher rate of displacement, the percentage recovery during the primary phase was noted to be slightly less than at the lower pressure differential. Also at the higher pressure gradient a slightly higher cumulative recovery was found to be necessary to effect complete removal of the displaced liquid.

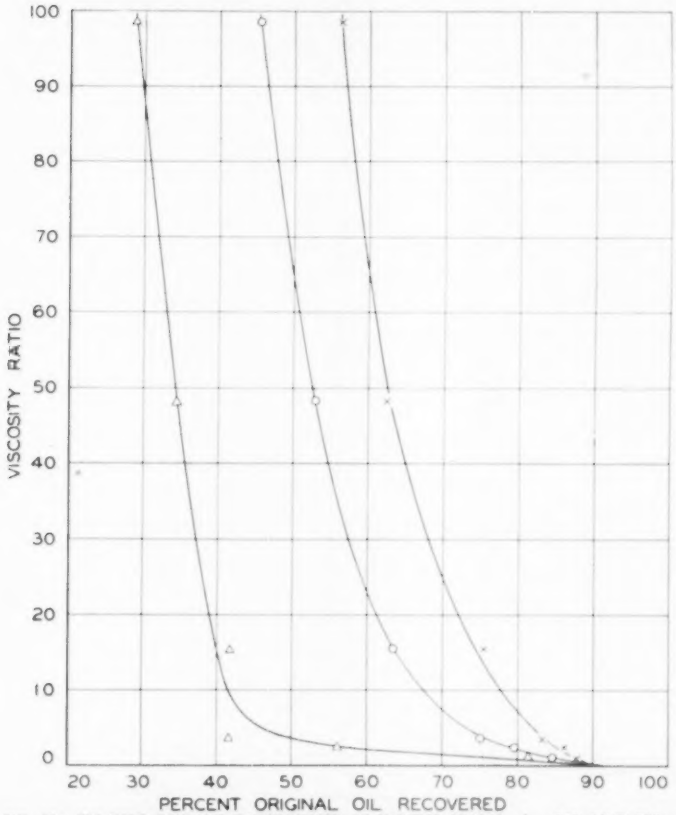


FIG. 18 — PER CENT ORIGINAL OIL PRODUCED AT VARIOUS STAGES. △ — PER CENT PRODUCED AT BREAKTHROUGH. 0 — PER CENT PRODUCED AT ONE PORE VOLUME TOTAL CUMULATIVE. X — PER CENT PRODUCED AT 1.95 PORE VOLUMES TOTAL CUMULATIVE.

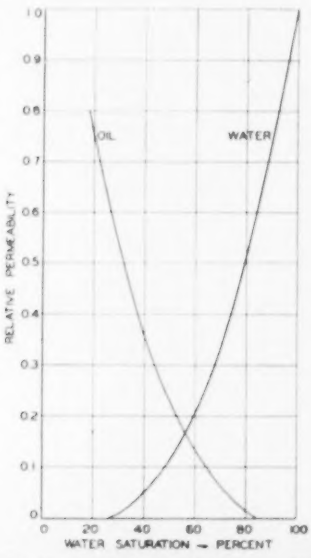


FIG. 19 — RELATIVE PERMEABILITY TO OIL AND WATER (AFTER LEVERETT, AIME, 1939).

These results are in agreement with those shown by Hendrix and Huntington[4] in their Fig. 3.

During the horizontal displacement test there was some visual evidence of a separation of displaced and displacing liquids due to difference in their densities. Therefore, vertical runs were made for comparison but only on the water-sugar solution displacements. The displacement histories on horizontal runs are shown in Fig. 4 and on vertical runs in Fig. 5. Fig. 7 compares one particular set of such runs for the same viscosity ratio. It was noted that the curves for horizontal runs show a hump after breakthrough but that the curves for vertical runs do not. Data from both horizontal and vertical runs are plotted in the correlations of Fig. 8, 9, and 10. From these plots it can be noted that the effects of gravity were probably not very important.

To further compare the results of the two types of displacement, the percentage recoveries at breakthrough for all runs were plotted in Fig. 10. All data can be represented by a single function from which individual observations do not deviate markedly. As pointed out previously, however, the water-sugar solution displacement can approach 100 per cent efficiency at zero viscosity ratio whereas the water-oil must approach a value of 91 per cent.

Further correlation was attempted between the observed data on water-oil displacement and calculated histories by the method of Buckley and Leverett.[3] The method will not be described here. Basic to the calculation are relative permeability curves. Such curves were not procured for the systems studied but inasmuch as they were very close to unconsolidated sands it was assumed that the relative permeability curves of Buckley and Leverett would apply. Fig. 19 shows the curves used for the calculations.

After several intermediate calculations the method gives a distribution of water saturation as a function of distance, U, along the linear system being flooded. Different distributions are calculated for different values of total cumulative liquid injected. Fig. 20 gives the results of such saturation distribution calculations for the case where the viscosity ratio was 1.04. From this figure and from the data necessary to calculate it, there was also obtained a calculation of per cent oil in the efflux as a function of cumulative throughput. These results are given in Fig. 21 along with experimental observations for the same viscosity ratio. The agreement in this case is quite good.

Fig. 22 gives an overall comparison between the calculated results for recovery during the primary phase as given by Buckley and Leverett and experimental results for the same quantity in the present work. The curves for the two sets of experimental data shown here are as taken from Figs. 8 and 18. Buckley and Leverett's calculations were not carried on for a system strictly analogous to the experimental ones described. They assumed a system containing connate water originally, a condition not used in the experiments being reported. However, their calculation of per cent water saturation at breakthrough should be comparable to per cent recovery at breakthrough from a system containing no connate water.

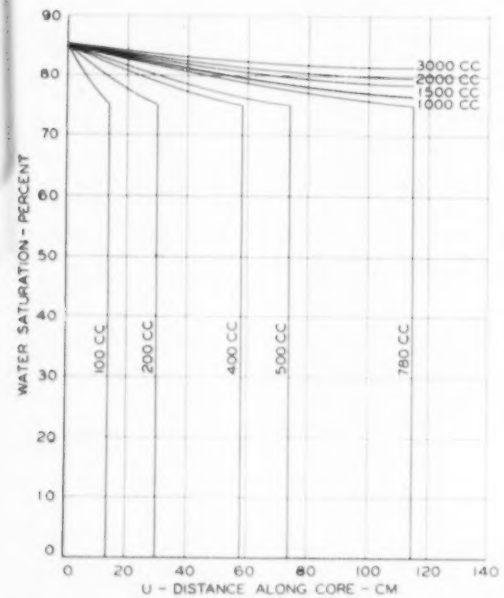


FIG. 20 — CALCULATED DISTRIBUTION OF WATER SATURATION AT VARIOUS VALUES OF TOTAL CUMULATIVE, BY METHOD OF BUCKLEY AND LEVERETT FOR OIL-WATER VISCOSITY RATIO EQUAL TO 1.04.

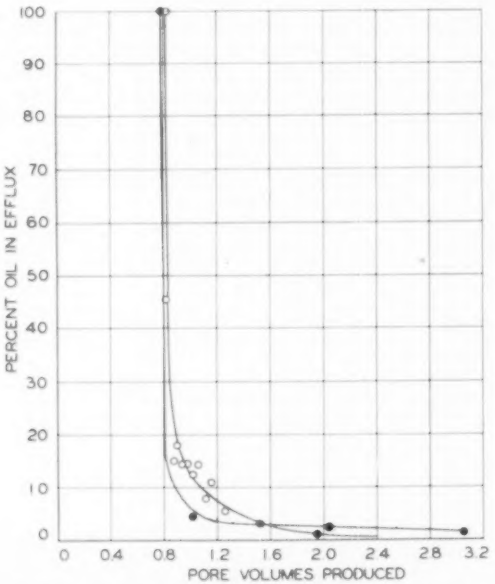


FIG. 21 — COMPARISON OF EXPERIMENTAL DATA WITH CALCULATED PERFORMANCE. 0 — EXPERIMENTAL DATA OIL-WATER VISCOSITY RATIO IS 1.04. ● — POINTS TAKEN FROM CALCULATED DATA OF FIG. 20.

It is significant to note that a water flood at the highest viscosity ratio of 98.6 produced only 29 per cent oil at breakthrough. This approaches the values ordinarily expected for gas displacement. It is suggested that the difference in mechanism between a water-drive and a gas-drive may be very slight if viscosity ratios are identical.

The comparison of the water-oil displacement results to a gas-oil displacement is further shown in Fig. 23, where water-oil ratios are plotted versus cumulative oil produced. For constant viscosity and pressure gradient conditions the water-oil ratio should be proportional to K_w/K_o. The cumulative oil produced can be plotted negatively as residual oil which would be proportional to an average oil saturation. Fig. 23 is comparable, therefore, to the familiar K_g/K_o versus oil saturation curve.

CONCLUSIONS

The general agreement between the behaviors of the two types of displacements observed in these experiments would lead to the thought that the main forces to be considered are viscous rather than interfacial. The interfacial forces undoubtedly control to a large degree the maximum possible displacement, i.e., the difference between 91 per cent and 100 per cent in the two instances reported. However, the manner of displacement where the interfacial forces were non-existent is comparable in a large degree to that where interfaces were present, which indicates that up to the final stages of displacement viscous forces were most important.

It is further suggested, therefore, that a theory of displacement of oil from porous media might be approached by a consideration of the displacement behavior between fluids which are mutually miscible. No complete analytical approach for this situation was found in the literature, even for simplified systems. The application of such data, aside from a contribution to a general theory of displacement, would be to the displacement of very mobile reservoir fluids by injected gases or to the recovery of oil by injected hydrocarbons.

These experiments point out the desirability of carrying on a water flood under conditions of as low a viscosity ratio as possible. Flooding at high pressures before solution gas is liberated, or flooding with waters containing high amounts of salts would both be advantageous from this standpoint. A further suggestion from these experiments would be that a high efficiency of displacement could be obtained by displacing reservoir liquids with other hydrocarbon liquids. Practically, however, this would not be feasible unless the displacing hydrocarbon could be readily recovered, a situation which could possibly be met by the use of a close cut, high vapor

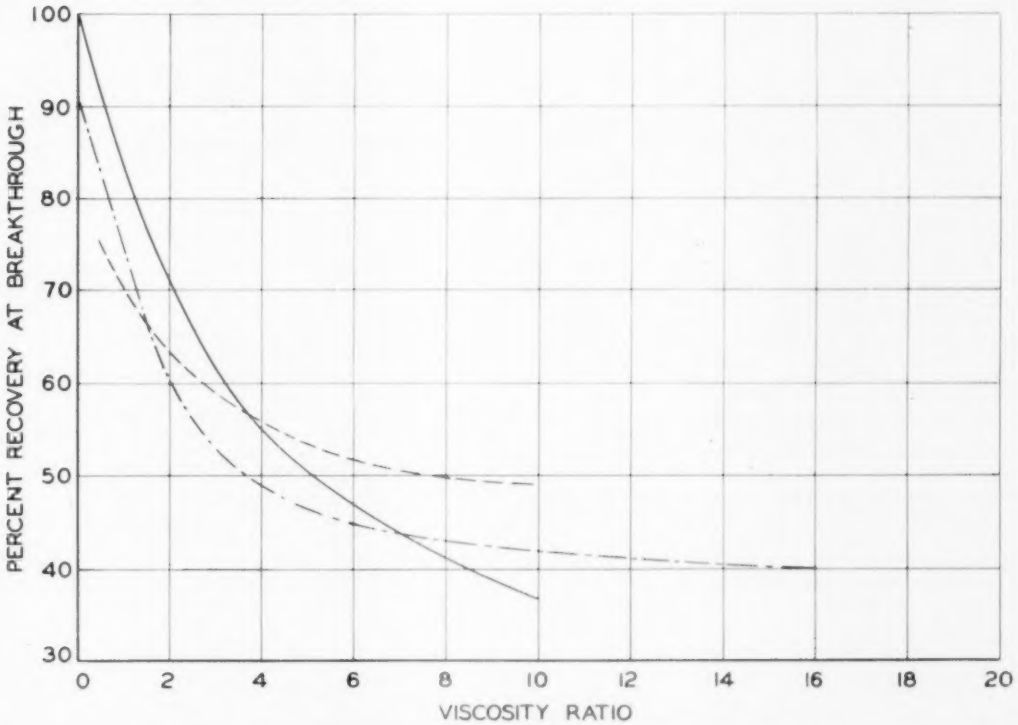


FIG. 22 — COMPARISON OF PER CENTS PRODUCED AT BREAKTHROUGH
- - - - - - - CALCULATIONS OF BUCKLEY AND LEVERETT.
———— WATER-SUGAR SOLUTION DISPLACEMENTS.
— · — · — · — WATER OIL DISPLACEMENT.

Table I

Summary of Results on Water-Water Solution Displacements

Run No.	Tube Position	$\frac{\mu_o}{\mu_w}$	$\frac{\mu_w}{\mu_w}$	$\frac{\Delta p}{\mu_w}$	Pressure Gradient	Pore Volumes Recovered at Breakthrough	% of Original Fluid Recovered at One Pore Volume Cumulative	Cumulative Pore Volumes Necessary for Complete Recovery
3	Horizontal	8.1	0.894	9.1	220 mm Hg	.38	72.7	4.0
4	Horizontal	3.8	0.894	4.25	220 mm Hg	.55	85.8	2.6
2	Horizontal	2.08	0.894	2.35	220 mm Hg	.66	89.7	1.86
5	Horizontal	2.05	0.874	2.35	760 mm Hg	.585		
11	Horizontal	1.0	0.876	1.14	220 mm Hg	.94	97.0	1.30
1	Horizontal	0.855	1.95	0.44	220 mm Hg	.96		1.18
7	Vertical	3.7	0.874	4.25	220 mm Hg	.55		2.1
9	Vertical	1.95	0.854	2.29	220 mm Hg	.67		1.85
6	Vertical	0.874	3.7	0.24	220 mm Hg	.97	98.0	1.11

Table II

Summary of Results on Water-Oil Displacements

Run No.	$\frac{\mu_o}{\mu_o}$	$\frac{\mu_w}{\mu_w}$	$\frac{\Delta p}{\mu_w}$	Pressure Gradient	Pore Volumes Recovered at Breakthrough	% of Original Fluid Recovered at One Pore Volume Cumulative	Total Pore Volumes Through at Termination	Cumulative Recovered at Termination
1	63.5	0.644	98.6	20 psig	29.0	45.5	2.70	62.0
3	33.0	0.68	48.53	20 psig	34.5	53.0	4.39	68.4
4	10.3	0.665	15.49	20 psig	41.8	63.3	6.09	89.0
5	2.21	0.63	3.51	20 psig	41.8	75.0	6.13	88.4
6	1.52	0.63	2.41	20 psig	56.1	79.6	4.72	89.7
2	0.835	0.80	1.04	20 psig	81.6	84.7	1.95	87.8

pressure fraction, which could be vaporized from the reservoir after displacement was complete.

It is apparent that the ratio of viscosities between displaced and displacing fluids is an important consideration in attempting to evaluate the success of displacement. Further examination of this concept might lead to control of maximum displacement efficiency by control of the viscosity of the displacing medium. The consideration of this concept might suffice also to compare gas and water displacements more fruitfully.

The experiments described here have been necessarily simplified. Experimentation on the displacement of oils by hydrocarbon liquids in the presence of connate water would be among desirable future experiments. Further simplification would also be desired in order to better understand the water-sugar solution displacement as a basis for theoretical calculations on water-oil or gas-oil displacements.

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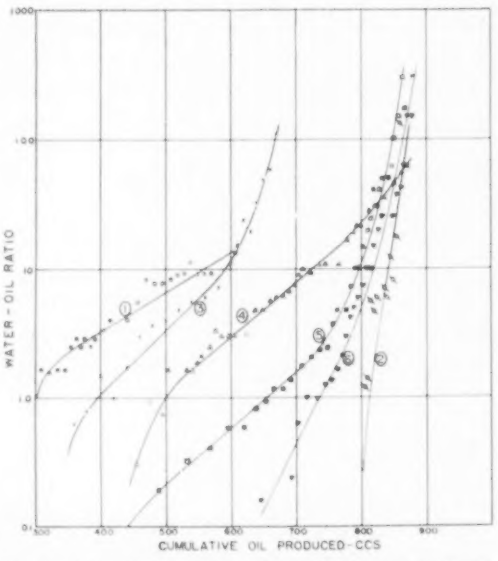

FIG. 23 – DISPLACEMENT HISTORY DURING SECONDARY PHASE TO SHOW SIMILARITY TO K_o/K_w CURVES. NUMBERS INDICATE RUN NUMBERS FROM TABLE II.

ANALYSIS OF FRACTURED LIMESTONE CORES

FRANK C. KELTON, MEMBER AIME, CORE LABORATORIES, INC., DALLAS, TEXAS

ABSTRACT

A method is outlined for the analysis of large cores, developed primarily for the purpose of obtaining reliable data on fractured or vugular limestones.

Porosity and fluid saturations are determined by a modified Dean-Stark extraction after initially bringing the samples to 100 per cent liquid saturation by a vacuum-pressure method. Horizontal permeabilities on the whole samples are determined in two directions, parallel and perpendicular to the direction of principal fracturing.

Results are presented for various types of formations. A comparison is made between data obtained by this special method and the method of conventional analysis, and discussion is given of the relative advantages and limitations of each. In view of this comparison a modified method for the analysis of fractured and vugular formations is proposed, which method retains the advantages of the previously outlined techniques but gives promise of speeding up the analysis.

INTRODUCTION

For many years the greater part of the production in the Permian Basin was from formations of Permian and Pennsylvanian age. While production from these formations is still the predominant production, deeper prospecting has brought to light older formations with oil productive characteristics. Attempts to core these deeper horizons were at first usually characterized by poor recovery. The old rule of thumb, "good core recovery — poor well" was originated and remained in effect until recently. With the advent of diamond coring and the increased efficiency in drilling and coring operations, the old adage has lost its significance. Formations of Devonian, Silurian and Ordovician ages were successfully cored with varying degrees of recovery. The cores thus obtained were surprising and in some cases disappointing. Good recovery from these formations led to speculation as to the feasibility of analysis and the meaning of data obtained from conventional analysis. Commercial laboratories were engaged to analyze these cores, and their results indicated that data obtained by conventional methods would be of little value. From visual inspection it was apparent that in many cases the effective porosity for storage of hydrocarbons, and permeability, were contained largely in fractures and solution cavities rather than in the primary crystalline structure of the formation. In other cases the solution cavities augmented the effective porosity of the primary crystalline structure, or fractures enhanced the permeabiilty of the latter so that the formation might respond favorably to acidization and become commercially productive. Since the spacing of the cavities and fractures was often comparable to the core diameter, it was evident that the entire core should be analyzed instead of small fragments.

On the basis of these observations, commercial laboratories were requested to devise a system of analysis which would yield data of practical value. Procedures have accordingly been developed which seem to meet this requirement, and to date nearly 12,000 large core samples have been analyzed. It is the purpose of this paper to describe the methods used, to present typical results for several fractured formations and to compare the data obtained by this special analysis with that obtained by conventional analysis. Certain modifications and alternative procedures are finally suggested to speed up the analysis.

CORE ANALYSIS PROCEDURE

Fluid Saturations and Porosity

The core sample, in segments up to 15 in. in length, is marked, weighed and examined under ultra-violet light to determine the presence of oil saturation. If present, the approximate quantity of oil and its location on intercrystalline, fracture or vugular surfaces is noted. This information is carefully recorded. The degree of fracturing and/or vugular development is also noted. The sample is then placed in a pressure cell and the air evacuated with a high speed vacuum pump. This evacuation is continued only long enough to reduce the pressure to approximately the vapor pressure of water in order not to remove excessive amounts of water. Water is admitted to the cell and allowed to penetrate the sample under atmospheric pressure, filling the pore space initially occupied by air and replacing the small amount of water removed by evacuation. Pressure up to 200 psi is applied to force water into the smaller capillaries, and the sample is left sub-

[1]References at end of the paper.

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merged under presure for an hour or longer. It is then removed from the cell, surface water wiped off, and re-weighed. The gain in weight is a measure of the residual gas content of the original sample. If large surface vugs are present an alternative procedure is used to prevent them from draining fluid, as will be discussed later.

The sample, now fully saturated with oil and water, is placed in an extraction pot, Fig. 1, and covered with toluene. The pot is placed in an insulated oil bath, Fig. 2, connected to a jacketed condenser tube, and allowed to heat up until the water of the sample and the toluene are vaporized. This process is similar to the familiar Dean-Stark extraction; as the water is condensed it drops into the receiving tube and collects at the bottom while the condensed toluene runs back into the pot. The water is drained from the receiving tube at intervals and measured.

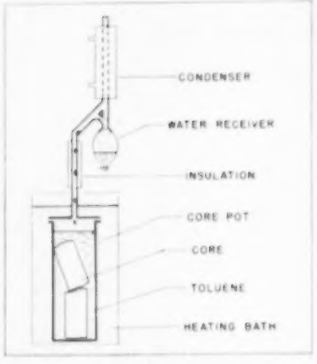


FIG. 1 — EXTRACTION APPARATUS SCHEMATIC

The largest part of the water in the sample is removed after one day's extraction, but the remainder comes over very slowly. Typical rates of water removal are shown for various formations in Fig. 3. Since it is necessary to determine the water content to within a fraction of a cubic centimeter in order to be able to determine the oil content acurately, the process is continued until the amount of water removed daily has dropped to 0.1 to 0.3 cc. This may require from three days to three weeks or even longer; the average time is about one week. During this time the oil content of the core sample is being replaced by toluene. If the visual examination showed oil saturation only on fracture planes and/or vugular surfaces, the extraction is asumed to be complete when there is no sensible gain in water in the receiving tube. If, on the other hand, the examination indicated oil in intercrystalline pore spaces, the extraction of oil may not be complete, and in this case the sample is removed from the pot and placed in an oversize soxhlet extractor where extraction with toluene is continued.

After extraction is complete the sample is placed in a constant temperature oven and dried for a period of one to two days. After cooling to room temperature it is re-weighed. The loss of weight, less the amount of water measured during the extraction, is the weight of the oil contained in the sample. This weight is corrected for an assumed density of oil to give the volume of oil in the sample. The summation of oil and total water gives the pore space of the sample, since the original gas content has previously been replaced by water.

A representative number of samples are immersed in water until capillary penetration of water has for practical purposes ceased, and their bulk volumes determined by the bouyancy or apparent decrease in weight when re-immersed in water. For the purpose of this measurement of bulk volume it is necessary only that no appreciable further penetration of water occurs during the second immersion; this is easily realized even though the samples are far from being 100 per cent saturated. These bulk volumes together with the dry weights give apparent densities, and these divided by one minus the respective fractional porosity give true grain density. An average true grain density figure is thus obtained, which is used together with the extracted weights of the other samples to determine their grain volume, and pore volume is added to give bulk volume. Pore volume divided by this bulk volume gives the porosity.

Permeability

The extracted sample, or the largest segment if the sample consists of more than one piece, is placed in the cylindrical holder shown in Figs. 4 and 5. The sides of the core are covered with two rectangular rubber gaskets, with openings whose length extends to within 1 to 1½ in. of the shortest length of the core and whose width extends over about one fourth the circumference. Two sections of split pipe of suitable diameter and with hinged pieces along their sides to provide a

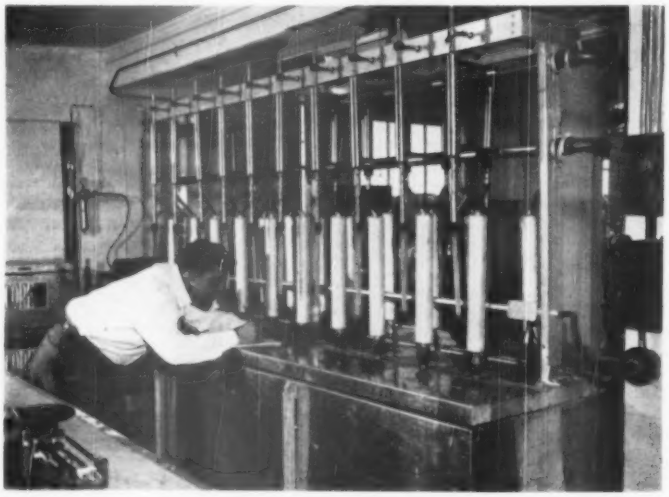


FIG. 2 — EXTRACTION APPARATUS

good fit, are placed around the gaskets, and a number of stranded wire cables are wrapped around the pipe. By means of a crank and worm gear these cables are tightened simultaneously so that considerable pressure is applied to all sides of the gaskets. This seals the core except for the two rectangular openings in the gaskets, a thin line along the sides of the core between the gaskets, and the ends of the core.

Air pressure is applied to the opening on one side of the core, and the rate of air flow out of the other side is measured directly by means of a burette and soap film so that no back pressure is exerted on the downstream side. Permeability is calculated as though the flow were uniformly distributed across the rectangular cross section between the gasket openings and through the length between the straight edges of the gasket openings. Corrections are then applied to take into account the nonlinearity of flow and the loss through the ends of the core and through the slits between gaskets.

The orientation of the core in the holder is such that the flow is across the direction of principal fracturing. The permeability so obtained is designated as K_{max}. The core is then turned 90° in the holder and permeability again measured. This is called K_{min}.

The correction applied to take care of the loss of air through the ends of the core is called the shape factor. Typical values of this factor, for a 3 in. core, are shown in Fig. 8. This shape factor is proportional to the fraction of entering air that gets to the gasket opening on the opposite side of the core. It may be noted that for the length of core usually available and the length of the seal between the gasket opening and the ends of the sample, the shape factor generally lies between 85 per cent and 95 per cent, i.e., a relatively small loss to the ends of the core. In addition to the above shape factor, a constant factor is applied to take care of the widening of the flow lines and loss of air at the sides between the gaskets, as may be visualized by reference to Fig. 4.

The above correction factors were derived by extensive experiments on a synthetic core of nearly uniform permeability. The flow through a series of

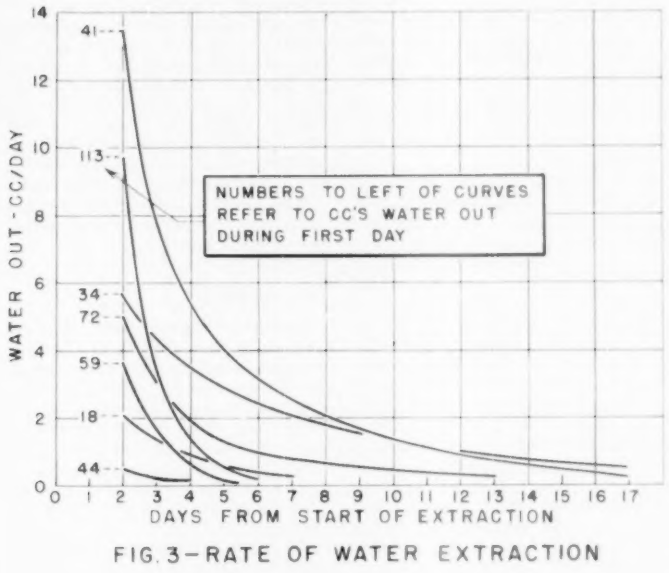

WATER OUT - CC/DAY
DAYS FROM START OF EXTRACTION
NUMBERS TO LEFT OF CURVES REFER TO CC'S WATER OUT DURING FIRST DAY
41
113
34
72
59
18
44
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
0 2 4 6 8 10 12 14
FIG. 3—RATE OF WATER EXTRACTION

FIG. 3—RATE OF WATER EXTRACTION.

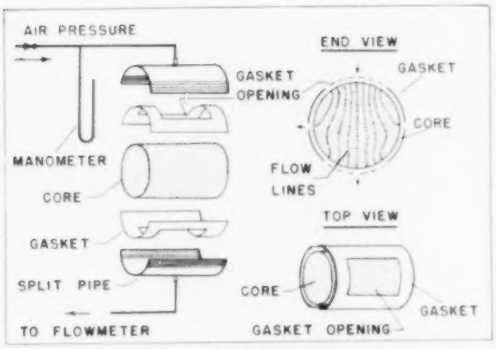


FIG. 4—CLAMP TYPE PERMEAMETER SCHEMATIC.

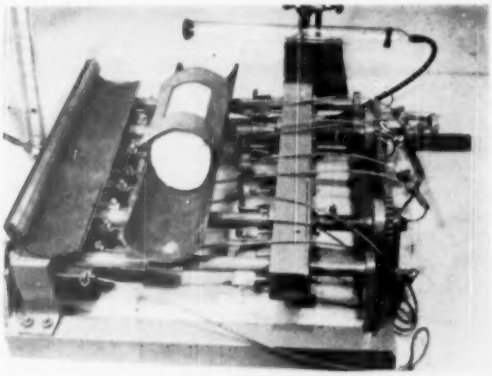


FIG. 5—CLAMP TYPE PERMEAMETER.

gasket openings was measured using a long core, and the series of measurements repeated after cutting off 2 cm at a time from each end of the core. A direct measurement of the permeability of each such section of the core was then made. A subsequent check was obtained from electrolytic model experiments simulating the non-linear flow through the core.

DISCUSSION AND ALTERNATIVE PROCEDURES

Fluid Saturations and Porosity

It may be noted that two checks are available on the porosity as determined by the above outlined procedure. If the sample, after extraction, is allowed to cool under toluene and then weighed prior to drying, the weight of toluene divided by its specific gravity furnishes a check on the porosity. The agreement is generally found to be good. Another check is furnished, after extraction and drying, by resaturating the sample with water and determining the weight increase. The agreement here is also good. For example, a series of such measurements on seven samples of porous limestone gave a porosity value of 10.06 per cent by toluene and 10.13 per cent by resaturation. On eight low porosity samples of the same formation, the corresponding averages were 1.30 and 1.27 per cent respectively. On another formation, the corresponding values were 10.01 and 9.40 per cent; on still another, 4.94 and 5.16 per cent.

If there is a question as to whether the volatility of a particular oil might give rise to incorrect saturations if vacuum is applied, the above technique of resaturation after extraction may be used. It is also used where there are a large number of surface vugs. In this case the extraction is carried out directly on the original sample. The extracted and dried sample is then sprayed with a webbing plastic material which bridges the gaps across the surface vugs. Additional plastic is applied until a coating is built up which is thick enough to prevent loss of water from the vugs but still permeable enough to permit the entrance of water when vacuum and pressure is applied. Actual experience has indicated that this method of applying a plastic coating is required in only a small percentage of cases.

In a check on six cores of $5^{3}/_{8}$ in. diameter, an average porosity of 7.63 per cent was obtained after extraction and resaturation with a 25 per cent brine (for purposes of electrical resistivity measurements), as compared to an average of 7.93 per cent from the original Dean-Stark extraction, and an average of 8.03 per cent from a gas expansion method. The last mentioned method will not be described in detail in this paper, but in brief consisted of using a large size Hassler holder to seal over the surface of a faced sample, followed by measurement of pressure change as air or helium was admitted to the evacuated sample. The accuracy of this porosity method is felt to be good, but it has the disadvantage of requiring extra steps in the procedure, i.e., sawing the core and subsequent drying, and also the attainment of pressure equilibrium is slow if the core matrix has extremely low permeability.

It may be mentioned that one example was encountered where the Dean-Stark extraction method failed to remove the water completely. If the procedure is applied blindly one would in this case come out with an incorrect high oil content and a low water content. In the example noted the apparent oil content was 0.6 per cent of bulk volume, the water content 0.8 per cent, the total porosity 1.5 per cent. The formation was a dense dolomitic shale, of permeability less than 0.001 md. It was evident, however, both from the appearance of the sample and the fact that the gas content was almost zero, that the formation was so tight that it would not give up all its water under the conditions of the extraction. This serves to emphasize that each analysis must be treated as an individual problem and solved accordingly.

Permeability

It has been suggested that the use of the above mentioned clamp type permeameter may give rise to considerable error due to the end effect when dealing with fractured core samples, i.e., there may be a channel connected to one end of the core which carries a disproportionately large amount of air. It is not denied that this may occur in some instances, but it is believed that the errors will be in both directions and will tend to balance out when a large number of samples are measured.

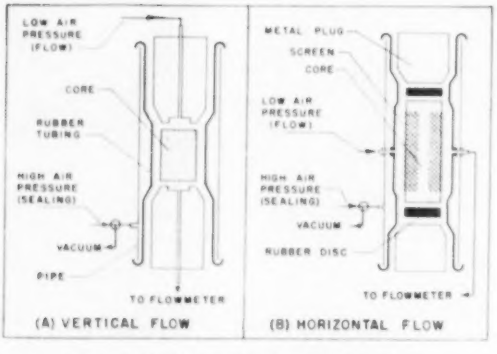


FIG. 6 — HASSLER TYPE PERMEAMETER SCHEMATIC.

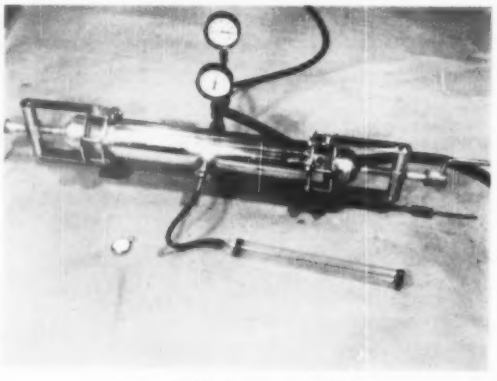


FIG. 7 — HASSLER TYPE PERMEAMETER.

The accuracy of any one measurement is not high, but the approximate magnitude of the "equivalent" permeability is at least indicated and the measured value does take into account the flow capacity of both the matrix and the fracture or vugular system. Measurements so far made on samples of intergranular porosity have shown reasonable agreement with permeabilities of drilled plugs from the samples.

A different type of permeameter has been devised, as shown in Figs. 6 and 7, not because it was felt that the open-end clamp type permeameter was not good, but to permit a different method of analysis which is described in the last part of this paper. Screens covering opposite sides of the core replace the rectangular gasket openings of the clamp type permeameter, and the remaining surface of the sample is sealed by rubber tubing and air pressure. This Hassler type permeameter may be used for both horizontal unidirectional permeabilities and vertical permeabilities on the same sample. It requires that the permeability sample be faced off on both ends with a diamond saw. The two sizes of this permeameter which have been built will accommodate core samples of diameter from $2\frac{3}{4}$ to $5\frac{3}{8}$ in., and length from 2 to 20 in. Shape factor corrections have been determined by three-dimensional electrolytic model experiments simulating the controlling factors in the fluid flow, i.e., the ratios of screen length and width to core length and diameter. The accuracy of permeability determination with this apparatus is probably slightly better than that of the clamp type permeameter; however, the latter is believed to be adequate for the purposes to which it is applied, considering the erratic and capricious nature of the permeability of fractured systems.

Matrix Measurements

A technique which was used in certain instances consisted of making measurements of total porosity by extraction and resaturation, and measurements of porosity on a number of small pieces of the matrix, using the difference as an indication of the amount of secondary, or fracture and vug porosity. This method has been described by Atkinson and Johnston.[1] Further experimental data in this connection is presented below. It is felt that this method is useful but is limited to those cases where the matrix is quite dense and the secondary porosity well defined.

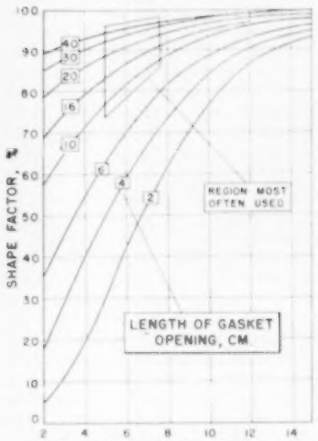


FIG. 8 — SHAPE FACTOR

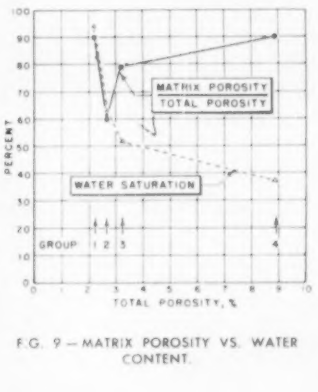


FIG. 9 — MATRIX POROSITY VS. WATER CONTENT.

ANALYSIS RESULTS FOR TYPICAL FORMATIONS

Matrix Measurements

After obtaining analysis results on large cores from a section of Ellenburger formation from the Fullerton field, additional measurements of matrix porosity and permeability were proposed in order to obtain a clear understanding of the relationships involved. Fortunately the available samples showed a rather wide variety of characteristics ranging from dense and finely fractured to spongy, vuggy formation. Accordingly, on the basis of the special analysis results only, four groups of samples were selected. Group 1 consisted of 14 samples with very low gas bulk (from 0 to 0.29 per cent) and low oil bulk (0 to 0.40 per cent). Group 2 contained 13 samples of intermediate gas bulk (0.41 to 1.52 per cent) and low oil bulk (0 to 0.16 per cent). Group 3 contained 15 samples of intermediate gas bulk (0.06 to 0.89 per cent) and intermediate oil bulk (0.17 to 2.10 per cent). Group 4 contained 7 samples of high gas bulk (1.43 to 5.63 per cent) and high oil bulk (1.05 to 2.40). In general, group 1 consisted of dense samples with limited fracture development, group 2 had somewhat larger fractures and some open vugs, group 3 showed more development of intergranular porosity, and group 4 samples were intergranular and/or highly vugular.

In Table I a summary is presented of average values of fluid contents, porosity and permeabilities by special analysis, and average values of porosity and permeability of matrix samples. The latter were small ($\frac{3}{4}$ in. diameter) drilled plugs. Matrix porosity was determined by the vacuum-saturation method, but pressure was not used. Fig. 9 is a graphic comparison of the

Table I

Matrix vs. Whole Core Data, Ellenburger, Fullerton Field

Group	1	2	3	4
Gas, % bulk	0.08	0.91	0.63	3.72
Oil, % bulk	0.06	0.06	0.88	1.84
Water, % bulk	2.07	1.65	1.66	3.27
% pore	94	63	52	39
Matrix porosity, % bulk	1.98	1.58	2.56	7.92
% total pore	90	60	81	94
Total porosity, % bulk	2.21	2.62	3.17	8.40
K_{max}, md	10	409	23	94
$K_{90°}$, md	0.6	1.2	10	38
Matrix K, md	0.3	0.2	0.3	3.7

averages of water saturation (as per cent of pore space) with the average ratio of matrix to total porosity, for the four groups.

Table I and Fig. 9 show agreement, considered good for the number of samples represented, between the water content for groups 1 and 2 and the matrix porosity. However, this agreement disappears for groups 3 and 4. This illustrates quantitatively what had been inferred, i.e., that matrix porosity measurements would be an approximation to the water content of the large cores, and hence useful in reserve estimates, only when the matrix is dense and representative pieces can be selected such that no small vugs or intergranular porosity is included.

The magnitudes and ratios of K_{max} and $K_{90°}$ in the different groups reflect the amount and distribution of secondary porosity between fractures and vugs.

Fig. 10 shows photographs of six core samples from the above groups together with the corresponding special core analysis data. Out of these, samples 50 and 96 are from group 1, sample 91 from group 2, samples 32 and 78 from group 3, and sample 29 from group 4.

Average Data for Several Formations

Table II presents a summary of special analysis data for three types of formation. Between 300 and 500 samples are included in each set of data. The group of samples listed as "low porosity fractured formation" consisted primarily of Ellenburger and Devonian. The "fractured limestone" group included relatively high porosity samples with considerable fracture and vug development. The "non-fractured dolomite" group was comprised of samples from three crystalline dolomite formations possessing negligible fracture development. It is of interest to note the average water saturations, 60.0, 45.8 and 41.8 per cent of pore space respectively. These decrease in the same order that the $K_{90°}$ values increase. It should be pointed out, if the average measured total water saturations seem high compared to the values usually associated with such formations, that these averages include values for the lowest porosity samples as well as the high porosity samples, and that no attempt was made to differentiate between "barren" and "productive" pay. The percentages of samples with K_{max} less than 0.1 millidarcys were 29 per cent, 5 per cent and 4 per cent for the three respective groups. The average oil saturations were, respectively, 16.6, 12.4 and 15.0 per cent of pore space. On the premise that the measured water content is equal to the connate water content, the calculated values of reservoir oil in place are, respectively, 73, 381 and 432 bbl per acre ft.

The maximum individual values of K_{max} in the three groups of samples of Table II are, respectively, 5,060, 27,400 and 970 millidarcys. These may be compared to the permeability values reported by Bulnes and Fitting[2] ranging up to 2,670,000 millidarcys and porosities up to 36.5 per cent, for $3\frac{1}{4}$ in. test plugs cut from a cavernous limestone. The average values of K_{max} and $K_{90°}$ shown in Table II are quite respectable values, and their ratios reflect the degree of fracturing of the three groups of samples. It is probable that reducing sample size and length of flow in permeability measurements on fractured and vugular formations tends to cause a poorer permeability distribution as compared to larger samples. That is, in two series of permeability measurements on small samples and on large samples from the same formation, the measurements made on small samples would show more extremely high and more extremely low values than the measurements made on large samples.

The data on the fractured limestone of Table II are further split into groups acording to porosity range, as shown in Table III. The two lowest porosity groups, 0-3, 3-6 per cent, are also divided into two subgroups according to whether K_{max} is less than or greater than 0.1 millidarcy. The regular trends in the oil, water and gas saturations as functions of porosity are pointed out. The water and oil saturations are plotted in Fig. 11 as "Field B," where they are compared with the corresponding water and oil saturations of a considerably lower porosity fractured Devonian formation, "Field A." It may be noted from Fig. 11 that the water saturation for the highest porosity group in Field B is practically the same as the water saturation for the next highest porosity group, in contrast to what one might expect from capillary considerations. This same effect has been noted in other cases; in some, the water saturation curve shows a decided minimum. This may be due to one of several physical causes. It may be a reflection of the connate water characteristics of the reservoir, caused by qualitative changes in the character of the pore space. Or it could be due to differences in relative permeability characteristics in the low and high porosity formation.

Table II

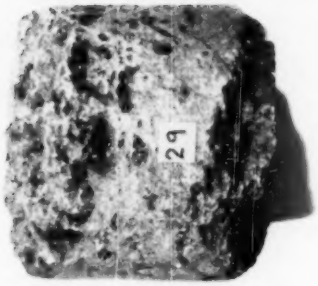
Summary of Average Data for Three Types of Formations

Formation:	Porosity % Bulk	Water % Bulk	Water % Pore	Oil % Bulk	Oil % Pore	K_{max}, md Aver.	K_{max}, md Range	$K_{90°}$, md Aver.	$K_{90°}$, md Range
Low-porosity fractured formation	2.38	1.41	60	0.39	16	96	0-5060	7.8	0-756
Fractured limestone	9.05	4.14	46	1.12	12	106	0-27400	12	0-313
Non-fractured dolomite	8.72	3.65	42	1.31	15	42	0-970	19	0-857

Table III

Breakdown by Porosity Groups of Data on a Fractured Limestone

Porosity Range, %	0-3		3-6		6-10	10-15	>15
Permeability md	<0.1	>0.1	<0.1	>0.1			
Number Samples	12	75	8	88	94	105	99
Porosity % Bulk	1.57	1.89	4.34	4.36	7.82	12.43	17.53
Oil % Pore	0.9	4.5	8.6	7.5	12.7	16.7	19.9
Water % Pore	85.1	73.9	59.7	55.0	42.4	30.5	29.7
Gas % Pore	14.0	21.6	31.7	37.5	44.9	52.8	50.4
K_{max}, md	0.04	11	0.05	133	335	28	28
Range	0.00-0.10	0.13-228	0.00-0.08	0.11-9,680	0.08-27,400	0.00-334	3.01-793
$K_{90°}$, md	0.03	3.33	0.02	11	10	16	18

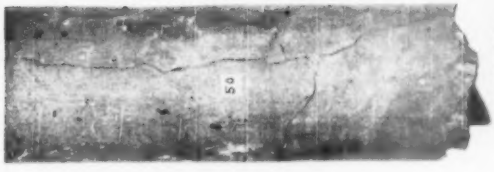


SAMPLE 29

Porosity	8.66%
K_{max}	23 md
$K_{90°}$	0.3 md
Gas	65%
Oil	21%
Water	14%

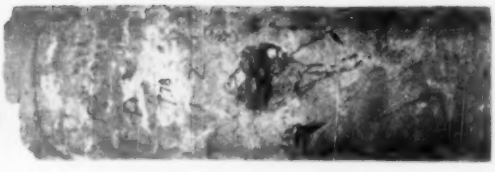
SAMPLE 32

Porosity	1.60%
K_{max}	108 md
$K_{90°}$	24 md
Gas	9%
Oil	36%
Water	55%



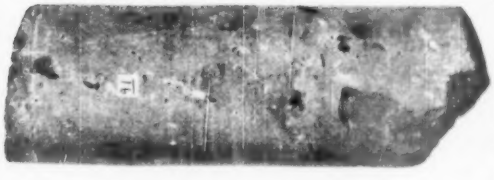
SAMPLE 50

Porosity	2.02%
K_{max}	124 md
$K_{90°}$	1.9 md
Gas	3%
Oil	0%
Water	97%



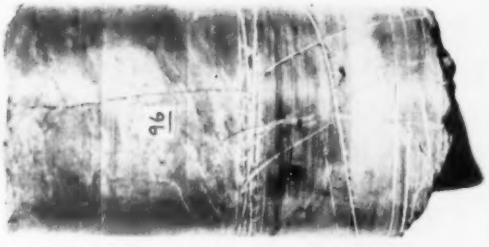
SAMPLE 78

Porosity	4.17%
K_{max}	125 md
$K_{90°}$	25 md
Gas	22%
Oil	11%
Water	67%



SAMPLE 91

Porosity	2.87%
K_{max}	3.1 md
$K_{90°}$	1.6 md
Gas	38%
Oil	3%
Water	59%



SAMPLE 96

Porosity	2.00%
K_{max}	15 md
$K_{90°}$	006 md
Gas	17%
Oil	5%
Water	78%

FIG. 10 — DATA ON ELLENBURGER SAMPLES.

Flushing of pore space with water from the drilling mud may have occurred and subsequent expulsion of water by liberated gas as the core was raised to the surface may have resulted in a final water saturation higher than the original connate water saturation. However, another possible cause is a statistical phenomenon which is often overlooked, but is known definitely to be of appreciable effect. The water saturations are averaged in groups with porosity as the controlling parameter. Since there is not a one-to-one correspondence between individual values of porosity and saturation, the average saturation for the next to highest group includes some low values which correspond to the porosity group below it and some high values which correspond to the porosity group above it. The average saturation for the highest porosity group can draw upon some values corresponding to the porosity group below it, but none for a higher porosity group, therefore, the average saturation for this end group is higher than would be the case if there were a still higher porosity group present. Incidentally, it may be noted that if this statistical effect did not exist, the average values of K_{max} and $K_{90°}$ for the highest porosity group of Table III would be higher, and perhaps more consistent with the values from the adjacent group if the presumption is made that the permeabilities for the adjacent group are not greatly influenced by fracturing.

Fig. 12 shows the permeability averages by groups for the fractured limestone of Table III, as compared to the corresponding data for the non-fractured dolomite samples of Table II. The fractured limestone permeability averages exhibit a significant feature in that the greatest permeability ratios occur for the intermediate porosity groups 3-6 and 6-10 per cent, whereas for the inter-crystalline dolomite the trend is for both permeabilities to increase steadily with porosity, with a gradual decrease in the ratio between K_{max} and $K_{90°}$.

In concluding this section on typical core analysis data for fractured formations, it may be remarked that the interrelationships between the measured quantities appear very similar to those for sandstone or non-fractured reservoirs, but with certain differences in the magnitudes of the porosity and in the directional character of the permeability. If one considers the fractured reservoirs in terms of larger volumetric units, the differences in reservoir behavior between these and sandstone reservoirs become a matter of degree, not of kind. It would appear that the core analysis of fractured reservoirs, once considered an impossibility, is now well on the way to becoming a useful tool in reservoir engineering. Continued study based in part on this tool should in time contribute materially to our understanding and evaluation of such reservoirs.

COMPARISON OF SPECIAL VS. CONVENTIONAL CORE ANALYSIS

The comparison betwen special and conventional analysis which is discussed here is not concerned with obvious differences which arise from the failure of conventional analysis to properly take into account the effect of fractures or large vugs, but rather with the basic differences due to the respective methods applied to formation which should lend itself to analysis by either method.

A portion of each sample used for special analysis was set aside and run by conventional methods of analysis. A total of 296 samples were run by each method. These samples were from three different reservoirs of crystalline dolomite. The extent of fracturing was

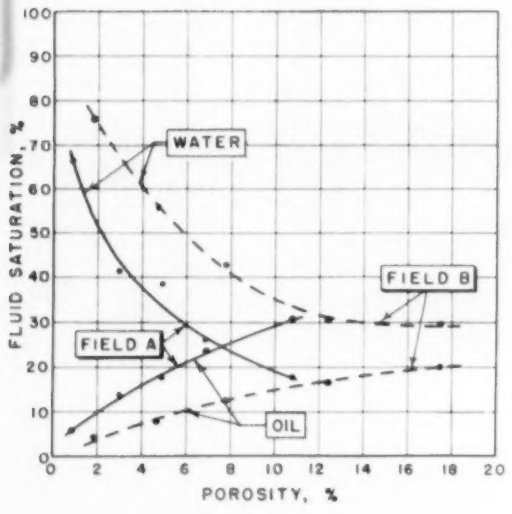


FIG. 11 — SATURATIONS VS. POROSITY FOR TWO FRACTURED FORMATIONS.

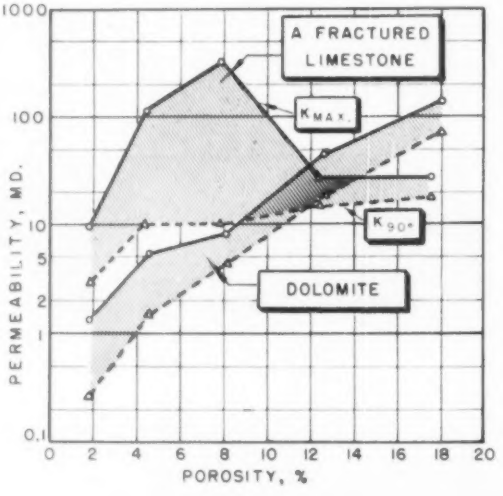


FIG. 12 — PERMEABILITY VS. POROSITY.

Table IV
Comparison of Special and Conventional Analysis

Dolomite	Special Analysis	Conventional Analysis
Porosity		
% Bulk	8.7	9.6
Oil		
% Bulk	1.3	1.2
Water		
% Bulk	3.7	2.2
Gas		
% Bulk	3.7	6.2
K_{max}		
md	42.1	26.9
K_{∞}		
md	18.9	26.9

so slight that it can be neglected insofar as its effect on porosity and fluid saturations is concerned, although possibly not in regard to permeability. The resultant average values for porosity, oil, water and gas bulk, and K_{max}, K_{∞} and conventional permeability, are shown in Table IV.

In the conventional analysis, a 180 gram sample of formation was retorted to arrive at water and oil content. Corrections were applied which had proved applicable to sandstone and presumably to higher porosity lime and dolomite. The gas bulk was measured on a separate 20-40 gram sample by injecting mercury at 750 psi presure into the gas-filled pore space, with corrections for the compressibility of mercury and its closer conformation to the chamber walls as pressure is applied. Porosity was calculated as the sum of the oil, water and gas bulk. Permeability was measured on a drilled plug from $\frac{3}{4}$ to $1\frac{1}{4}$ in. in diameter.

Referring to Table IV, it is noted that porosity by special analysis is 9 per cent lower than porosity by conventional analysis. The oil contents by the two methods checked closely, 1.3 per cent of bulk volume by special as against 1.2 per cent by conventional analysis. The difference in porosity is seen to be due to the combined effect of a higher water bulk by special analysis and a higher gas bulk by conventional analysis.

To realize the reasons for these differences it is necessary to go back to the original data and to study critically the individual steps of the methods and calculations. In the special analysis there is evidence (e.g., weight of core saturated with toluene) that in some cases the measured gas content is slightly low. In the oil content determination there are sources of possible error which, however, tend to compensate each other except in extreme cases which can usually be anticipated. Incomplete extraction of oil by the toluene results in low measured oil content, whereas incomplete removal of water gives high measured oil content. In general, the measurement of water content of the sample is considered quite accurate.

In the conventional analysis the water content is appreciably lower than by special analysis, and there is reason to believe that more time should be allowed for distillation of water from the sample. By taking the final water reading in the retorting instead of an intermediate water reading, the water bulk for the data of Table IV would be increased from 2.2 to approximately 3.3. The water is read at an intermediate time in the case of sandstone samples in order to allow for combined water or water of crystallization, but apparently in the case of dolomitic formation the water is held in the fine capillaries in free rather than in combined form, and the reason the water is slow in coming over during the distillation is that the permeability of the matrix is so low.

The high measured gas bulk in conventional analysis seems to be the most important source of discrepancy. It should be realized that in the low porosity material involved we are stretching the limits of accuracy of this measurement. The reason for the high gas bulk probably lies largely in the fact that there is a surface effect and that the mercury conforms more closely to the grains when pressure is applied. This effect causes a greater percentage error when the total pore space is low. It is not believed that measurement of total porosity by the Washburn-Bunting method would appreciably increase the accuracy since in this method there is an error from absorption of air on the pore surfaces, and this error would be appreciable due to the number of fine capillaries and the large surface area. It is possible that a helium porosimeter would work satisfactorily. At any rate, investigation is being made as to ways to reduce the error in the gas bulk measurement of conventional analysis, and also to choose suitable retorting conditions to improve the accuracy of the water measurement.

In summary, it is believed that the special analysis methods give somewhat more accurate fluid saturation and porosity values than conventional analysis, even on non-fractured formation. The special analysis may possibly tend to give slightly conservative values for reservoir oil in place. Conventional analysis on low-porosity formation which does not have fractures or large vugs has in the past probably given values for reservoir oil in place which are too high, but there is reason to believe that improvements in accuracy can be made here.

Individual foot-by-foot interpretations should not be made from special analysis data since examination reveals very poor correlation between porosity, fluid saturations and permeability of individual samples when fracturing or solution cavities are present. However, statistical examination of the overall data on a given reservoir does reveal relationships which should be useful in reservoir studies and reserve estimates. The need for analysis of all of the productive horizon is even more apparent than in the case of sand reservoirs.

POSSIBLE MODIFICATIONS OF SPECIAL ANALYSIS METHODS

A major limitation of the special analysis technique heretofore described is its slowness. This is a consequence of the size of the samples and the time required for complete extraction. Due to this long extraction time, even a large and expensive laboratory installation is limited in the number of samples it can turn out per day. The slowness of extraction is not the entire reason, of course, since the process involves a large number of separate time-consuming steps on which detailed and careful records must be kept. In order to obtain core analysis data of more immediate use for completion purposes, it would be highly advantageous to have a faster method.

It has been observed that some operators have insisted that special analysis rather than conventional analysis be made in cases where the fracture or vugular development of the formation was minor. Since in the past the analysis of small amounts of core had proved inadequate for all cases, this was probably a natural reaction or swing to the other extreme. However, for a good many formations, statistical considerations show that conventional analysis will be adequate, and should be chosen where quickness of results are important.

One compromise which should prove applicable in many cases would be to run conventional analysis except for permeabilities which would be run on the large cores as needed. This would be particularly suited to cores which are in part fractured and whose porosity is of the intergranular type or shows only small to medium size vugs. The contribution of fractures to the total porosity will in general be quite small.

For those formations on which special analysis is specifically required, three alternative modifications are proposed in order to shorten the time required to complete the analysis. These are as follows:

1. On those reservoirs where the oil section is known or can be determined by examination under ultraviolet light, it is proposed to saturate the samples as before, and then combine, say, 100 ft of contiguous cores in one large-scale Dean-Stark extraction apparatus. In this way the total water content and the total oil content is determined for the combined group of samples which represents all of the core available and individual measurements of porosity and permeability are made on the separate samples. The composite oil and water content of each 100-ft section can be used to establish reserves, and should be as useful as individual values since for this purpose the individual values would have to be combined anyway.
2. It is proposed to take 6 to 9-in. specimens of core for extraction, face them off, and determine permeability using the Hassler type permeameter shown in Figs. 6 and 7. In this apparatus vertical as well as two horizontal permeabilities can be measured. Adjacent 9 to 12-in. specimens of core can be taken for determinations of porosity and fluid content. For this purpose the core will be crushed by a rock crusher to the size of walnuts or smaller. Preliminary tests indicate that the extraction will be complete in 1 to 2 days by this procedure. The total analysis time will of course not be shortened a comparable amount since we are actually adding additional steps of cutting, crushing, handling and calculating; however, the statistical average characteristics of the formation should be affected only to a very small extent by thus using $\frac{1}{2}$ to $\frac{2}{3}$ of the sample size that has been previously used in special analysis.
3. Other entirely different methods of analysis are possible, such as vacuum distillation, which shows possibilities of being made into a fast and acurate method.

It is believed that the above described procedures can be developed to be as accurate as the methods of special analysis originally used and described in this paper. It is hoped they will be used to speed the accumulation of reservoir data on the increasingly important class of fractured and vugular reservoirs.

ACKNOWLEDGMENT

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VAPOR-LIQUID EQUILIBRIUM DATA ON THE SYSTEM NATURAL GAS-WATER-TRIETHYLENE GLYCOL AT VARIOUS TEMPERATURES AND PRESSURES

JOE A. PORTER,* BLACK, SIVALLS AND BRYSON, INC., KANSAS CITY, MO., AND **LAURANCE S. REID,** UNIVERSITY OF OKLAHOMA, NORMAN, OKLA., MEMBER AIME

Gas dehydration plays an important part in the production of natural gas. Effective dehydration prevents formation of gas hydrates and the accumulation of water in transmission systems,[2,6,7] insuring uninterrupted gas deliveries at maximum efficiency under the most adverse weather conditions. At the present time, most gas companies require a maximum water vapor content of seven lb per million standard cu ft of gas, so that virtually all gas tendered for sale must be dehydrated to meet this specification.

For a number of years it has been common practice to produce gas and gather it at a common point for dehydration prior to discharge into the transmission system.[1,8,11,16,17] However, higher transmission line pressures, long gathering lines and relatively low ground temperatures have made it necessary to dehydrate gas at, or near, individual wells in order to gather gas from a number of newly developed fields without unusual difficulty. Where gas has been dehydrated at pressures ranging from 300 to 800 psi in the past, future trends indicate that these processes may be operated at pressures as high as 2,000 psi.

Economics of gas dehydration are of great importance, particularly where facilities must be provided to process relatively small quantities of gas, such as the production from an individual well. Although the adsorption of water vapor from gas on a granular sorbent material such as activated bauxite, activated alumina, or one of the alumina-silica gels is highly effective and produces virtually "bone dry" gas, the cost of a small unit of this type is substantially greater than that of an absorption process which, through proper selection of the absorbing liquid, will dehydrate the gas sufficiently to meet pipe line specifications. For this reason, a great deal of emphasis has been placed on the development of small, inexpensive dehydration units[2,14] and the search for more effective absorbent liquids has been intensified.

A wide variety of methods for dehydrating gas are known[1] and many of these have been used in industry. Earlier applications of the absorption process employed concentrated solutions of calcium and lithium chlorides as the absorbent. The severe corrosion problems inherent in handling these solutions and the relatively small dew point depressions obtained caused early abandonment in favor of, or conversion to, diethylene glycol when it was found that aqueous solutions of this organic liquid were more hygroscopic than the brines and were noncorrosive. Processes employing diethylene glycol-water solutions are widely used for gas dehydration at pressures ranging as high as 1,200 psi.[12,13,15] At nominal pressures a dew point depression of 45° to 50°F may be obtained and the data of Russell et al.[14] indicate that a minimum dew point is obtained from the effluent gas at a pressure of approximately 1,200 psi when the gas is in equilibrium contact with a 95 per cent by weight diethylene glycol solution. In a number of instances the dew point depression obtained with diethylene glycol-water solutions is not sufficient to produce a specification product without cooling the inlet gas. In a recent search for a better absorbent, triethylene glycol was used in a small commercial dehydration unit and subjected to rather exhaustive field tests.[2] The data obtained were encouraging and indicated that, at pressures ranging from 300 to 500 psi, triethylene glycol produced a substantially greater dew point depression than diethylene glycol. These results led to an investigation of the system natural gas-water-triethylene glycol in an effort to obtain vapor-liquid equilibrium data, to determine pressure limitations, and to develop other data pertinent to the design of gas dehydration processes.

A review of the literature has failed to reveal any data which permit reasonably accurate calculation of the vapor-liquid equilibrium conditions for a solution of water and triethylene glycol in contact with natural gas at high pressure. Since these constituents form a non-ideal system, the Poynting equation[20,21] or the usual combination of Raoult's and Dalton's laws[9,20,22] would not be valid. Correction of Raoult's and Dalton's laws by the use of activity coefficients[21] is not feasible for available data are insufficient for the prediction of the actual increase in the ratio of the activity of one component in the vapor phase to its activity in the liquid. Therefore, experi-

[1]References are given at end of paper.

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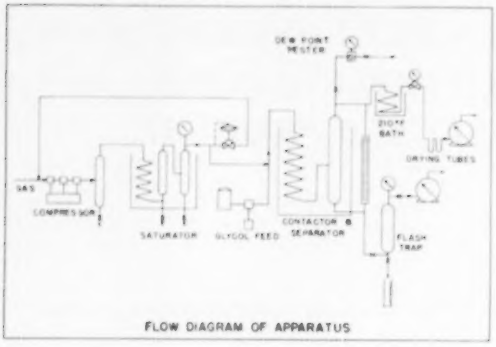
*American Gas Association Supply Men's Research Fellow in Chemical Engineering at the University of Oklahoma. This paper is a condensation of a thesis submitted by J. A. Porter in partial fulfillment of the requirements for the M.Ch.E. degree, conferred by the University of Oklahoma in August, 1949.



FLOW DIAGRAM OF APPARATUS

FIG. 1

mental equilibrium data were observed in the laboratory, using 95 per cent by weight triethylene glycol, 5 per cent water solution in contact with a relatively nitrogen-free natural gas at pressures ranging from 500 to 2,000 psig and at temperatures ranging from 60° to 100°F.

APPARATUS

The experimental apparatus used in this investigation is shown in Fig. 1 and is, essentially, a duplicate of the continuous flow system used by Russell[3] to investigate the system natural-gas-water diethylene glycol. In this system, the natural gas was compressed to the desired pressure by a three-stage Rix compressor and passed through a coil in a constant temperature bath to a saturator where the moisture content of the gas was adjusted to the desired level. Saturated gas from this vessel then passed through a gas scrubber where any entrained water was separated and removed from the gas. Saturation conditions were checked by dew point measurement of the gas at a point immediately downstream from this scrubber.[3]

A measured quantity of saturated gas was then passed to a second constant temperature bath containing the gas-liquid contactor and a separator. A measured quantity of 95 per cent triethylene glycol solution was pumped into the contactor coil by means of a gas-powered plunger pump so that the gas and glycol solution flowed concurrently in intimate equilibrium contact to the separator, where the two phases were separated and removed from the system.

The effluent gas stream was split, with one portion passing through a U. S. Bureau of Mines Dew Point Tester maintained at system pressure, thence to a pressure-reducing regulator prior to measurement at atmospheric pressure in a wet test meter. The second portion was passed to a second pressure-reducing regulator, thence to a train of drying tubes filled with anhydrous magnesium perchlorate where water and glycol vapors were adsorbed prior to measuring the gas in a second wet test meter. Gas from both meters was then vented to atmosphere.

The glycol solution was withdrawn from the separator at a constant rate in order to maintain a uniform level in that vessel. A portion of this solution was accumulated under pressure in a separate vessel, equipped with a high-pressure reflex liquid level gauge glass, where the solubility of gas in the glycol solution was determined at the end of each run.

Accessory apparatus included a special viscosimeter used to determine the glycol concentration of all solutions used in this investigation.[10]

EXPERIMENTAL MATERIALS AND TECHNIQUES

The natural gas used in this investigation was obtained from the mains of the Oklahoma Natural Gas Co. at Norman, Okla. A representative analysis of this gas is shown in Table I.

The triethylene glycol used was a technical grade obtained from the Carbide and Carbon Chemicals Division of Union Carbide and Carbon Corp. Physical constants and other data pertaining to this glycol are shown in Table II. The glycol was blended with distilled water to the desired concentration of 95 per cent by weight glycol and 5 per cent by weight water.

A specific operating procedure was used throughout the investigation which was developed from preliminary experiments. In pressuring the apparatus, the saturator was by-passed to prevent condensation of moisture in the system. When system pressure reached 200 psig, glycol injection was started. After the desired operating pressure was attained, the gas was turned through the saturator and the gas flow to the contactor was adjusted to a rate of six standard cu ft of gas per hour. The glycol injection rate was adjusted to 60 gal per Mcf of gas. These rates, and the established temperatures and pressures, were maintained constant throughout the run. After operating conditions were established, the system was operated for one hour before any samples were drawn for analysis or effluent gas dew points observed. At the end of this preliminary period, an inlet gas dew point was observed to start the run and the drying tube train was connected into the proper effluent gas stream. A total volume of approximately 20 standard cu ft of gas was passed through the drying tubes in order to minimize error. The weight of the glycol vapor in the effluent gas stream was obtained by difference, calculated from the pounds of water and glycol adsorbed from one cu ft of gas passing through the drying tubes, minus the pounds of water vapor per cu ft of gas as determined by dew point measurement in conjunction with the water vapor content correlation by McCarthy et al.[9] Prior to use, the adsorbent used in the drying tubes was saturated with hydrocarbons by passing dehydrated gas through the train, thus insuring that only glycol and water vapors would be adsorbed during the investigation.

Dew points of inlet and effluent gas were determined by means of a U. S. Bureau of Mines Dew Point Tester, using liquid propane as the refrigerant. Preliminary investigation of the effect of glycol vapors on the dew point of gases treated with triethylene glycol failed to reveal errors of the magnitude predicted by Reisenfeld and Frazier[11] so that the dew point method was accepted as adequate. It is interesting

Table I
Analysis of Natural Gas

Component	Gas Volume % or Mol %
Carbon Dioxide	0.70
Nitrogen	1.95
Methane	82.52
Ethane	8.20
Propane	3.67
Butanes	1.86
Pentanes	0.72
Hexanes	0.19
Heptanes and Heavier	0.19
	100.00

Specific Gravity (Re: Air = 1.000): 0.6932

Table II

Some Physical Constants and Properties of Triethylene Glycol[23]

Structural Formula	$HO\text{-}CH_2\text{-}CH_2\text{-}O\text{-}CH_2\text{-}CH_2\text{-}O\text{-}CH_2\text{-}CH_2\text{-}OH$
Molecular Weight	150.17
Specific Gravity at 20°/20°C	1.1254
Boiling Point at 760 mm Hg.	287.4°C
Decomposition Temperature	206.5°C
Solubility in Water	Completely miscible in all proportions

to note that the dew points obtained were sharp and unmistakable; wholly unlike the results of similar determinations on gases treated with diethylene glycol solutions. This is probably due to the fact that triethylene glycol exhibits approximately 15 per cent of the vapor pressure of diethylene glycol at the temperatures employed.

The water concentration of the glycol solution was determined using an adaptation[16] of the method proposed by Fried, Bigg and Jennings.[4] This method is based on the fact that the viscosity of a glycol-water solution is directly related to the glycol concentration. The specially constructed apparatus was calibrated at a constant temperature of 30°C using solutions of known concentrations prepared from a sample of 100 per cent triethylene glycol supplied by the Carbide and Carbon Chemicals Division of Union Carbide and Carbon Corp.

All glycol solution used in this investigation was collected, analyzed and re-blended to 95 per cent glycol concentration

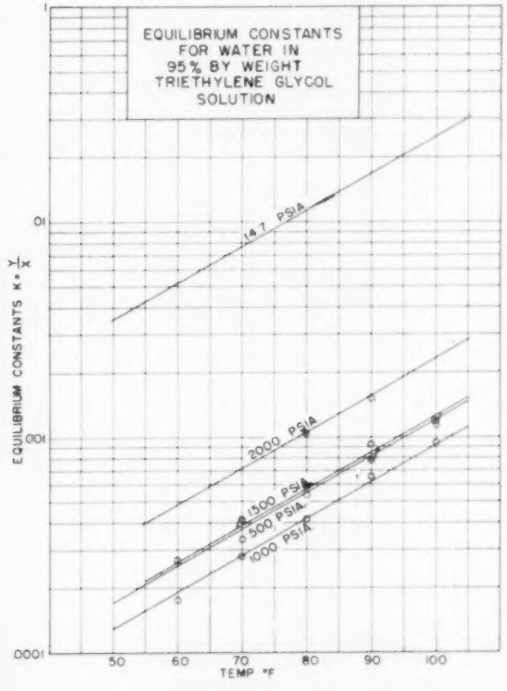


FIG. 2

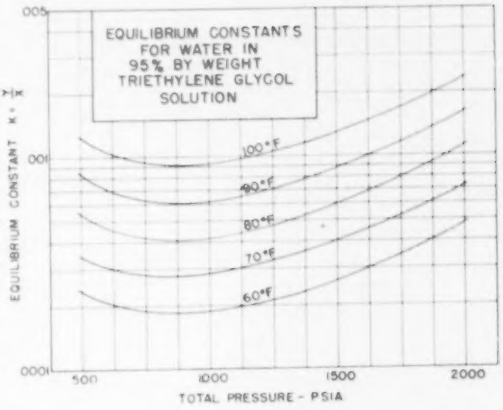


FIG. 3

by adding fresh glycol. Fresh solution requirements were small due to the fact that the glycol-gas circulation rate was so great that, even at 500 psig pressure and 100°F, the solution was diluted to but 94.0 per cent by weight glycol. At higher pressures and lower temperatures, the dilution was of the general order of magnitude of one to two-tenths of one per cent so that the equilibrium data obtained were, substantially, for 95 per cent glycol concentrations throughout the investigation.

Solubility of gas in glycol solution was determined by liberating the gas evolved from solution differentially and measuring it by means of a wet test meter. The gas was liberated at a very low rate so that the process was substantially isothermal. The volume of the residual glycol solution was measured in a standard 1,000 ml graduated cylinder.

Accuracy of the data obtained in this investigation is considered to be quite satisfactory. Dew point measurements were reproducible to 2°F. Determination of the glycol concentration of the various solutions was accurate to 0.1 per cent, and check determinations on gas solubility in glycol solutions varied from 3 to 5 per cent. The method employed for the determination of glycol concentration in the effluent gas proved unsatisfactory, particularly at pressures exceeding 1,000 psig and at the lower temperatures employed, due to the fact that it depended on a small weight differential between two relatively large weights. As this weight differential became progressively smaller the error became larger.

DISCUSSION OF RESULTS

The data obtained from this investigation are shown in graphical form for sake of brevity. Fig. 2 is a semi-logarithmic plot of the equilibrium constants for water, calculated from the observed data, versus temperature using pressure as the parameter. The curve for atmospheric pressure was calculated from published equilibrium data.[21] The best straight line has been drawn through the experimental data points for each higher pressure, parallel to the atmospheric isobar. From this plot the equilibrium constant for water may be obtained at intermediate temperatures. Fig. 3 is a cross-plot of Fig. 2, where the equilibrium constants for water are plotted versus system pressure with temperature the parameter. This plot indicates that, over the temperature range investigated, a mini-

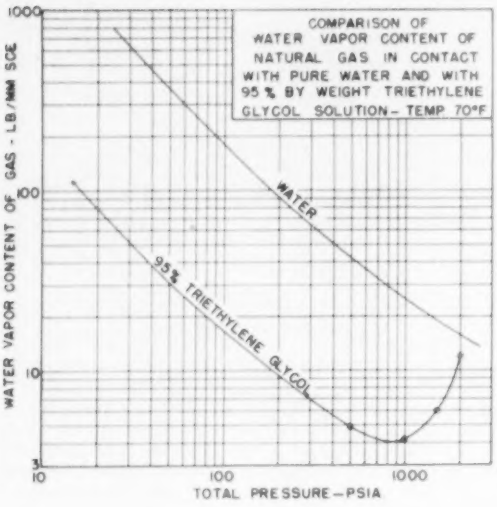


FIG. 4

mum value of K is found at a pressure of approximately 900 psia.

Figs. 4, 5 and 6 show graphical comparisons of the water vapor content of natural gas in equilibrium contact with (a) pure water, and (b) 95 per cent by weight triethylene glycol-water solution at temperatures of 70°, 80° and 90°F, respectively. It is of interest to note that the water vapor content of the gas in equilibrium contact with the glycol solution passes through a minimum in the pressure range 800 to 1,000 psia. An extrapolation of the glycol curve indicates a retrograde phenomenon at pressures exceeding 2,000 psia wherein water is stripped from the glycol solution by the gas. This indicated behavior has been verified by laboratory experiments conducted since the investigation was concluded. It is postulated that the pressure at which the two curves intersect would be increased by use of more highly concentrated glycol solutions.

If the gas entering the absorber is saturated with water vapor at the contact temperature, then the dewpoint depression is obtained by subtracting the dew point temperature of the effluent gas from the contact temperature. Dew point depressions for inlet saturation temperatures of 70°, 80° and 90°F may be determined from the data of Figs. 4, 5, and 6, respectively. However, dew point depression is plotted versus pressure for a constant inlet temperature of 80°F in Fig. 7. Inspection of the data of Figs. 4, 5, and 6 and similar data for temperatures of 60° and 100°F, not shown, indicates that there is virtually no difference in dew point depression resulting from varying the contact temperature from 60° to 100°F, indicating that the dew point of the effluent gas is a function of the inlet temperature and the system pressure. Fig. 7 shows that the maximum dew point depression is practically constant at pressures ranging from atmospheric to 500 psia where the differential temperature is approximately 60°F. At higher pressures, this differential temperature declines quite rapidly.

Data obtained showing the concentration of triethylene glycol in the effluent gas are presented in Table III. These data were found to be inconclusive at higher pressures and lower temperatures, because of the analytical method employed, but they are presented here to indicate the probable magnitude of the glycol vapor losses attending gas dehydration under comparable conditions. Further investigation of this phase of the problem is now under way, employing a modification of the analytical method used by Russell.[9]

The solubility of natural gas in 95 per cent by weight triethylene glycol-water solution at a temperature of 80°F and various pressures is shown in Fig. 8. These data are based on the volume of the residual solution measured after the gas was liberated. Solubility data observed at other temperatures employed in this investigation were in very close agreement

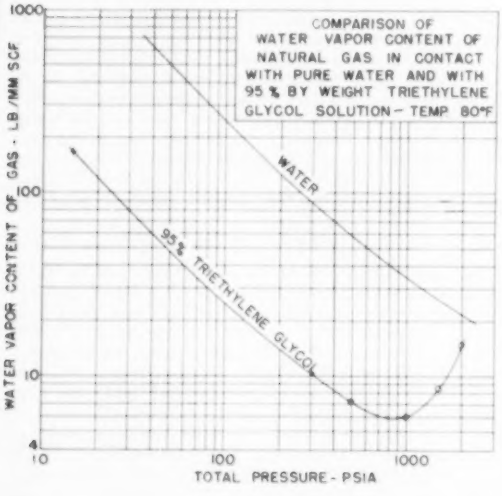


FIG. 5

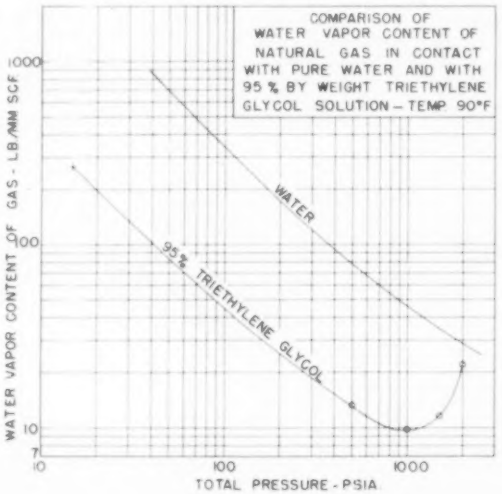


FIG. 6

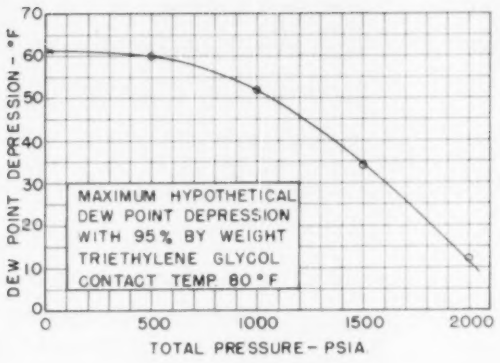


FIG. 7

Table III

Equilibrium Concentrations of Triethylene Glycol in the Vapor Phase at Various Pressures and Temperatures

Temperature °F	Lb of Glycol per MMSCF Gas
At 500 psia:	
60	2.71
70	0.52
80	0.21
90	0.35
100	1.75
At 1,000 psia:	
60	1.68
70	0.65
80	0.50
90	——
100	——

with the data of Fig. 8 so that this curve properly represents the solubility of gas in 95 per cent triethylene glycol solution at temperatures ranging from 60° to 100°F.

A comparison of some of the physical properties of triethylene glycol and diethylene glycol[9] suggests that the former is probably better suited for natural gas dehydration service. In the atmospheric temperature range, the vapor pressure of triethylene glycol is approximately 15 per cent of the vapor pressure of diethylene glycol, indicating that vaporization losses from atmospheric storage would be lower if triethylene glycol were used. Although the boiling points of the pure substances vary appreciably, 549°F for triethylene glycol versus 473°F for diethylene glycol, the aqueous solutions exhibit virtually identical boiling points in the range 95-98 per cent by weight glycol. However, the extent to which these solutions may be concentrated by application of heat at atmospheric pressure is limited by decomposition temperatures. Diethylene glycol has a decomposition temperature of 328.1°F[9] so that the maximum concentration attainable without deterioration due to progressive decomposition is slightly less than 97 per cent. On the other hand, triethylene glycol has a decomposition temperature of 403.7°F[9] which permits concentration of the solution to approximately 99 per cent by weight. In view of the fact that dew point depression is a function of glycol concentration under equilibrium conditions,[10] it follows that triethylene glycol can be used with greater effectiveness at operating pressures ranging upward to 1,100 psig.

CONCLUSIONS

The results of this investigation may be summarized as follows:

1. Sufficient experimental vapor-liquid equilibrium data have been obtained on the system natural gas-water-triethylene

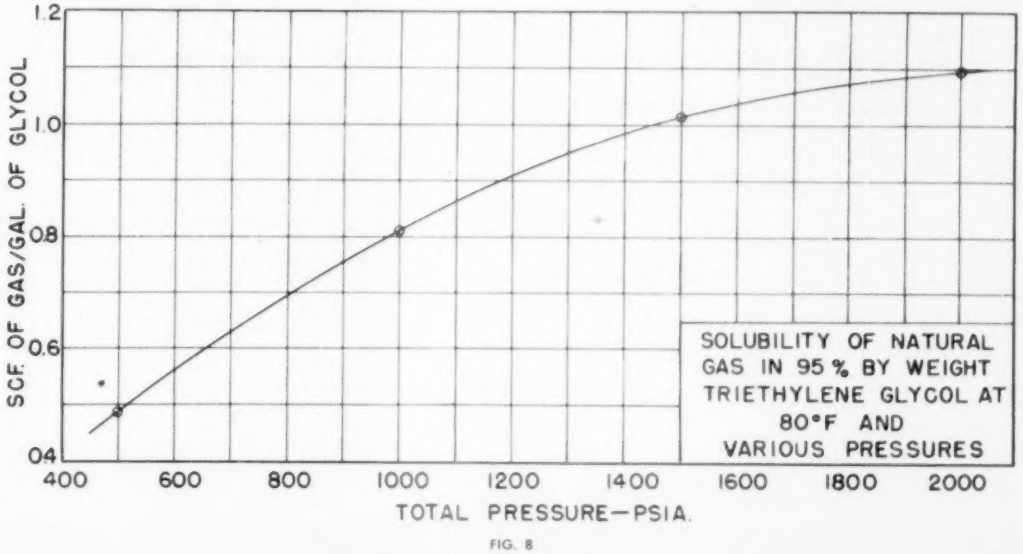


FIG. 8

glycol to permit design of gas dehydration facilities operating at temperatures ranging from 60° to 100°F and at pressures ranging from atmospheric to 2,000 psig.

2. Equilibrium dew point depression in a triethylene glycol dehydration system operating at a specific pressure is a function of the contact temperature alone, over the range of temperatures investigated.
3. The solubility of natural gas in a 95 per cent by weight triethylene glycol-water solution varies with pressure, but it is not a linear function of pressure. Variation in temperature has a negligible effect on gas solubility within the temperature range investigated.
4. The practical pressure limit for natural gas dehydration processes employing 95 per cent by weight triethylene glycol-water solutions is approximately 1,500 psig. The dew point depression diminishes rapidly at pressures greater than 1,000 psig.
5. At pressures as high as 1,100 psig, 95 per cent by weight triethylene glycol-water solution effects a greater dew point depression than a diethylene glycol-water solution of the same concentration.
6. Triethylene glycol has a lower vapor pressure and greater thermal stability than diethylene glycol.

ACKNOWLEDGMENTS

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Special thanks are due the Carbide and Carbon Chemicals Division of Union Carbide and Carbon Corp. for providing a sample of pure triethylene glycol and pertinent viscosity data, and to Black, Sivalls and Bryson, Inc., for donating the high-pressure glycol pump used in this investigation.

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THE WATER VAPOR CONTENT OF ESSENTIALLY NITROGEN-FREE NATURAL GAS SATURATED AT VARIOUS CONDITIONS OF TEMPERATURE AND PRESSURE

EUGENE L. McCARTHY, BLACK, SIVALLS AND BRYSON, INC., KANSAS CITY, MO.; **WILLIAM L. BOYD,** CONTINENTAL OIL CO., PONCA CITY, OKLA.; AND **LAURANCE S. REID,** UNIVERSITY OF OKLAHOMA, MEMBER AIME

ABSTRACT

Proper control of the moisture content of natural gas is essential to reliable operation of gas transmission and distribution facilities serving northern markets. The moisture content of natural gas is usually determined by dew point measurement at the existing pressure. For any gas of constant moisture content, the dew point varies with the pressure.

A correlation of the data of several investigators is presented in graphical form by the authors. These data were correlated by the authors and F. M. Townsend, C. C. Tsao, M. D. Rogers, Jr., and J. A. Porter, graduate students in chemical engineering at the University of Oklahoma.

Of particular interest are the hitherto unpublished low temperature data observed by Wickliffe Skinner, Jr., which are included in this correlation.

PRESENTATION OF DATA

The problem of interpreting water dew points, or saturation temperatures, of natural gas in terms of specific moisture content has increased in importance during the past decade because of extensive developments in the transmission and petro-chemical phases of the natural gas industry. Virtually all gas transported to northern and eastern markets must be dehydrated to a low water vapor content to prevent hydrate formation in transmission and distribution lines and resultant interruptions in gas deliveries. Complete dehydration is required in certain phases of the petro-chemical industry involving low-temperature operations.

It is a well-known fact that the water vapor content of pure hydrocarbon vapors and their mixtures at superatmospheric pressures cannot be predicted with accuracy by assuming validity of the ideal gas laws.[12] Earlier interest in the general problem was concentrated on the water vapor content of pure hydrocarbons and hydrocarbon mixtures in the pressure and temperature ranges common to gas and oil producing reservoirs in order to obtain fundamental data for the improvement of production techniques and the furtherance of reservoir studies. Excellent data are published for pressures ranging from atmospheric to 10,000 psig and for temperatures ranging from 100° to 460°F[2,3,10,11] and are found to be in close agreement. However, experimental data at high pressures and temperatures below 100°F are comparatively limited in scope.

Experimental data in the lower temperature range have been reported by Laulhere and Briscoe,[9] Deaton, et al.,[2,3] Hammerschmidt,[5,6] and Wade.[14] In general, the pressures employed in these investigations ranged from atmospheric to 1,000 psig while temperatures ranged from 32° to 120°F; i.e., the usual conditions encountered in gas transmission line operations. Additional data were reported by Russell, et al.[12] at pressures as high as 2,000 psig and covering a rather narrow atmospheric temperature range. In 1947, Hammerschmidt published a correlation of all available data,[7] in which the water vapor content of gases at saturation, under high pressure and low temperature, was predicted by extrapolation. In 1948, Wickliffe Skinner, Jr., presented data on the moisture content of a low nitrogen content gas at low temperature and at pressures ranging upward to 1,500 psia.[13] Comparison of Skinner's experimental data with the extrapolated data of Hammerschmidt revealed an appreciable variation in the lower temperature range, emphasizing the need for a new correlation which would rely on Skinner's data at lower temperatures.

Careful scrutiny of available data suggested that presence of an appreciable quantity of nitrogen in a gas mixture may affect its saturated moisture content so that data obtained from gases with more than three per cent nitrogen were not used in this correlation.

CORRELATION OF DATA

Data employed in this correlation are presented in Table I.

The data of Dodson and Standing,[4] McKetta and Katz,[8] and Olds, Sage and Lacey[10] were compared and found to be in close agreement so that the data of Olds, et al. re-plotted in a more convenient form by the Humble Oil and Refining Co.,[1] were used for temperatures of 100°F and above. Skinner's data were used for temperatures below 40°F. Between these intermediate temperature limits, the data of Hammerschmidt,[7] Wade[14] and extrapolated data of Olds, et al.[1] were tabulated

[1]References given at end of paper.

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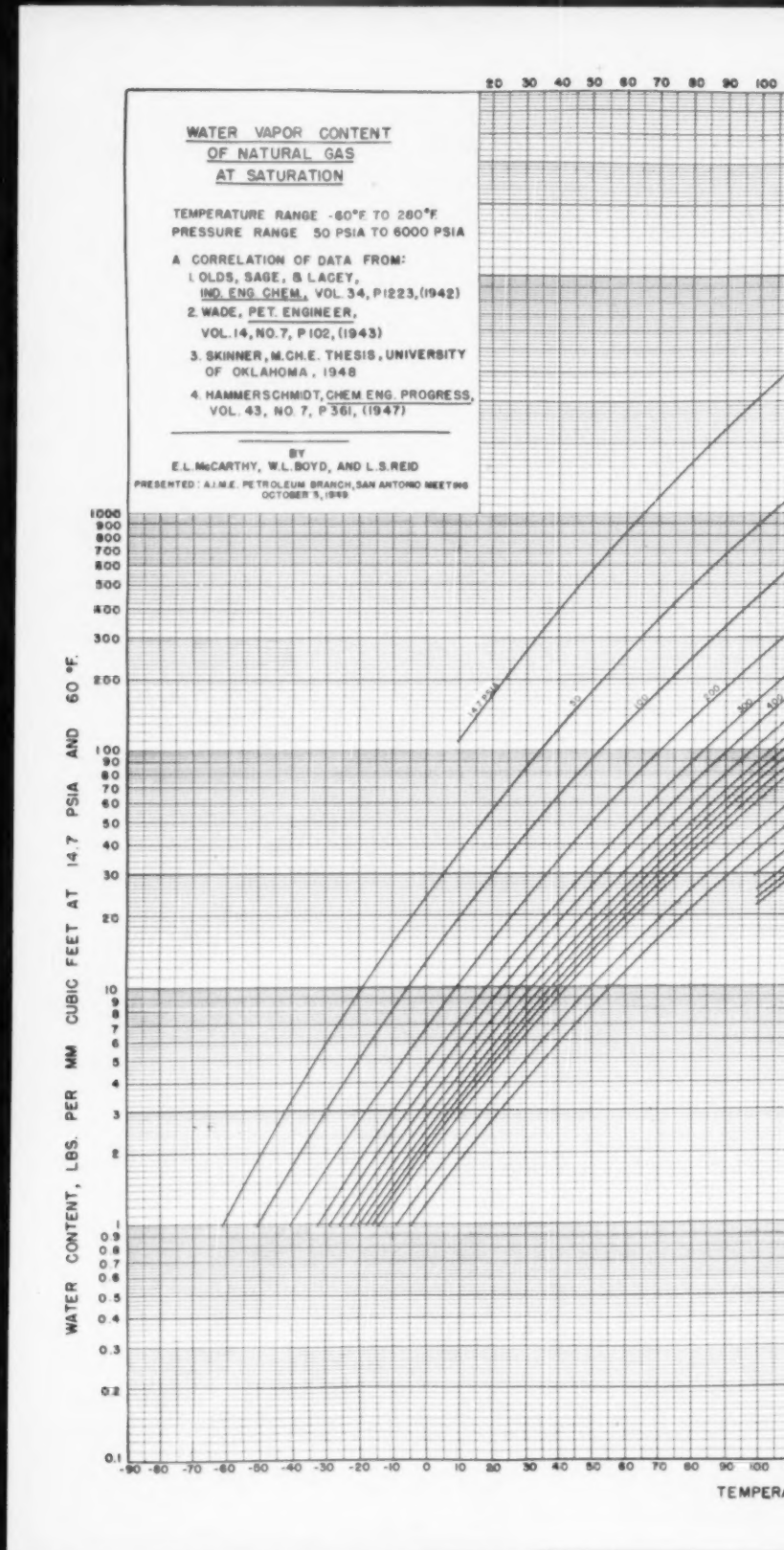
WATER VAPOR CONTENT
OF NATURAL GAS
AT SATURATION
TEMPERATURE RANGE -60°F TO 280°F
PRESSURE RANGE 50 PSIA TO 6000 PSIA
A CORRELATION OF DATA FROM:
1. OLDS, SAGE, & LACEY, IND. ENG. CHEM., VOL. 34, P1223, (1942)
2. WADE, PET. ENGINEER, VOL. 14, NO. 7, P 102, (1943)
3. SKINNER, M.CH.E. THESIS, UNIVERSITY OF OKLAHOMA, 1948
4. HAMMERSCHMIDT, CHEM ENG. PROGRESS, VOL. 43, NO. 7, P 361, (1947)
BY
E.L. McCARTHY, W.L. BOYD, AND L.S. REID
PRESENTED: A.I.M.E. PETROLEUM BRANCH, SAN ANTONIO MEETING OCTOBER 5, 1949
WATER CONTENT, LBS. PER MM CUBIC FEET AT 14.7 PSIA AND 60 °F.
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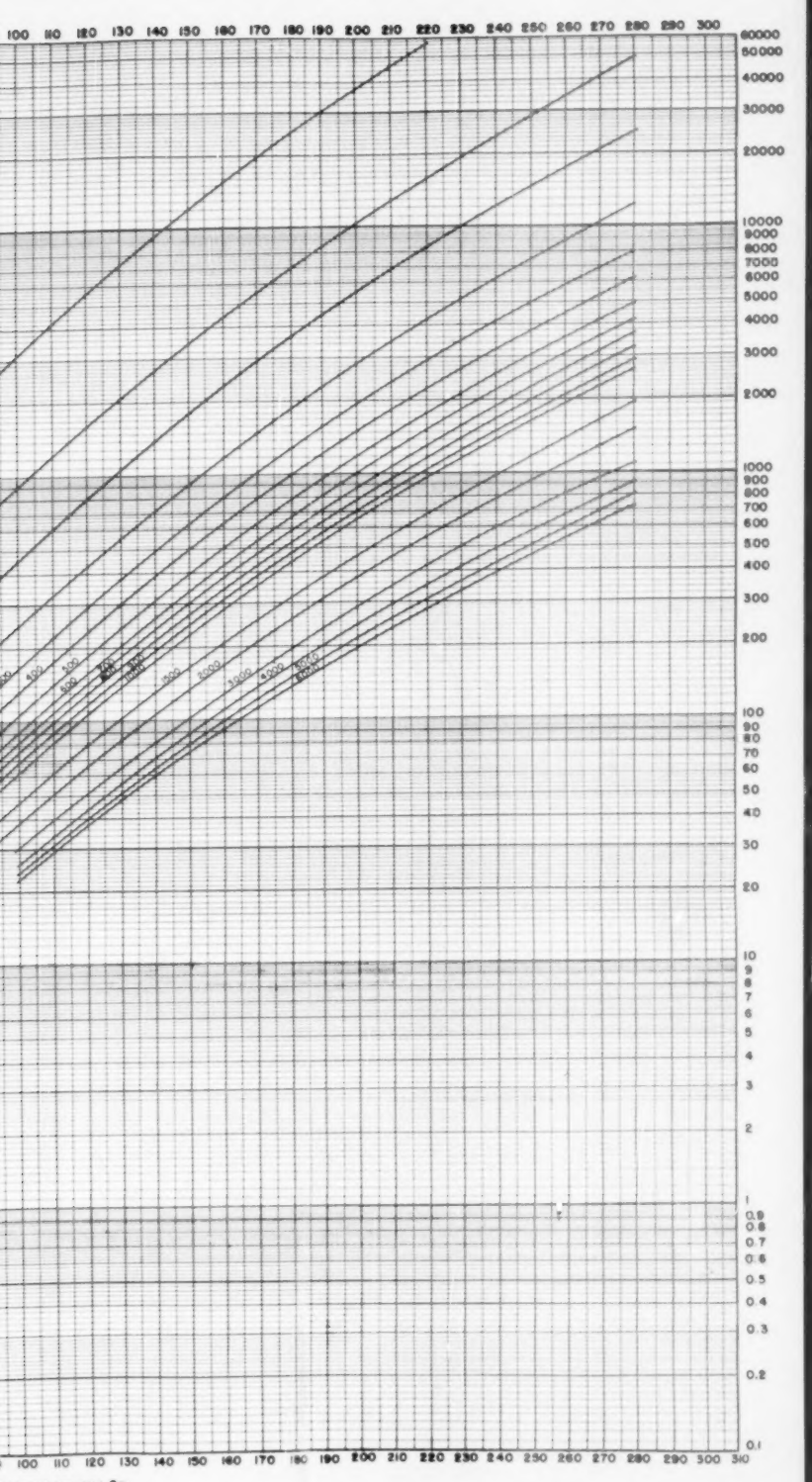
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EMPERATURE °F

Table I

Sources of Data Used in Correlating the Water Vapor Content of Essentially Nitrogen-Free Natural Gas at Saturation

Investigator	Reference	Pressure Range psig	Temperature Range
Hammerschmidt	7	50-2,000	20° to 120°F
Olds, Sage and Lacey	10	300-10,000	100° to 460°F
Skinner	13	30-1,500	−60° to 40°F
Wade	14	25-1,000	−10° to 120°F

and averaged. These average values, together with the smoothest curve drawn to join the data plots of Skinner and Olds, et al, determined intermediate values between 40° and 100°F. Accuracy of this method was confirmed by comparison with a Duhring plot of the data of Skinner and of Olds, et al, at 700 psia which was prepared by F. M. Townsend.* The water vapor content of gas at atmospheric pressure was calculated from the vapor pressure data of Zimmerman and Lavine.[15]

CONCLUSIONS

Experimental data concerning the moisture content of essentially nitrogen-free natural gases have been correlated and plotted versus saturation, or dew point, temperature using pressure as the parameter. Pressures range from atmospheric to 6,000 psia, while temperatures range from −60° to 280°F. These data have been used successfully in the production of gas from high pressure wells, in the design of dehydration processes and in the operation of high pressure gathering and transmission lines.

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*Graduate Student in Chemical Engineering, University of Oklahoma, Norman, Okla.

Oil And Gas Developments In Kansas During 1949

By J. B. Steele, Jr.,* Member AIME, and J. H. Page**

In keeping with the trend of other oil producing states in 1949, Kansas showed an increase over 1948 in almost every phase of its exploration and drilling programs. At the end of 1949, the accumulative production of Kansas was 1,992,272,933 bbl of oil, or 5.12 per cent of the accumulative total for the United States. The oil production of the state of Kansas for 1949, 102,873,779 bbl, is 5.54 per cent of the total for the United States for 1949, indicating that Kansas still remains an important source of national oil production.

PRODUCTION

Average crude oil production per day for Kansas for 1949 was 274,422 bbl. Daily allowable production for Kansas was about 295,000 bbl for the first two months of 1949; 275,000 bbl during March, April, May, and June; 250,000 bbl during July and August; 270,000 bbl up to December; and for December the allowable was 275,000 bbl. The apparent discrepancy between the 1949 crude oil production figure for Kansas of 100,164,092 bbl and a reported total of 102,873,779 bbl, is due to the inclusion in the latter figure of 2,709,687 bbl of casinghead gasoline.

Details of 1949 production by fields are shown in Table 1. Production and pool drilling data for 1949 in comparison with 1948 are shown below.

SUMMARY OF DRILLING OPERATIONS*

	1949	1948
Total wells completed	3,405	3,225
Oil wells	1,687	1,644
Gas wells	424	365
Dry holes	1,294	1,216
Per cent successful	62.0	62.3
Potential daily oil prod. added	921,585	668,929
Total oil production for year	102,873,779	110,298,134
Daily average production	281,846	302,186

*Figures do not include Eastern Kansas stripper operations.

The total potential of all wells in the state as of Jan. 1, 1950 was 2,483,218 bbl. The all-time high total potential of 8,201,960 bbl established in March, 1942, has shown a continuous decline, although the rate of decline has been reduced annually.

Kansas produced a total of 263,225,963 Mcf of gas during 1949, as compared with the 1948 gas production of 240,195,558 Mcf, or an increase for 1949 of 9.6 per cent over the year 1948. Productivity of new gas well completions was 5,989,157 Mcf, or an average of 14,226 Mcf per well. Of the 1949 gas production, the greatest percentage was from the Hugoton Field which was responsible for almost 85 per cent in 1949 in comparison to 77 per cent in 1948.

Approximately 60 per cent of the total well completions in the state were in seven counties, six of these counties being located on the Central Kansas Uplift in Western Kansas. These more active counties as shown by the total number of well completions are as follows: Barton, 399; Russell, 320; Rooks, 311; Butler, 275; Rice, 249; Stafford, 205; and Ellis, 192.

Of the more active counties, Russell shows the best record with only 36 per cent dry holes, followed by Butler with 37 ½ per cent dry holes, and Barton with 38 per cent dry holes. The poorest record is that of Ellis County with 45 per cent dry holes.

The overall average depth drilled for all wells was 3,300 ft, including 3,335 ft for oil wells, 2,757 ft for gas wells, and 3,451 ft for dry holes, and an overall average of 3,383 ft.

EXPLORATORY DRILLING

A list of the important exploratory wells drilled in Kansas during 1949 is found in Table 2. These are arranged with pool discoveries first, followed by the important dry holes, all in order according to townships south.

The table below lists the number of exploratory tests drilled in Kansas for 1949 in comparison with 1948.

EXPLORATORY DRILLING*

	1949	1948
Total exploratory tests	540	521
New oil pools	82	71
New gas pools	7	3
Dry holes	451	447
Per cent successful	16.5	14.2

*Figures do not include Eastern Kansas stripper areas.

The more active counties as shown by the total number

*District Petroleum Engineer, East and West Kansas Districts, Continental Oil Co., Route 4, Lyons, Kansas.

**General Manager, Eastern Kansas Gas Co., Iola, Kansas.

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TABLE 1A - OIL AND GAS PRODUCTION STATISTICS FOR EASTERN KANSAS IN 1949

LINE NUMBER	FIELD (County)[a]	PRODUCING FORMATION NAME AND AGE[b]	YEAR OF DISCOVERY	OIL PRODUCTION			GAS PRODUCTION			GAS/OIL RATIO[d] MCF/BBL	CONDENSATE PRODUCTION Thousands of Bbl	
				AREA PROVED ACRES	BARRELS TO END OF 1949	BARRELS DURING 1949	AREA PROVED ACRES	THOUSAND CU FT[c] TO END OF 1949	THOUSAND CU FT[c] DURING 1949		TO END OF 1949	DURING 1949
	Coffey											
1	Van Noy	Penn		1,300		11,209						
2		"Chat" Mbr.										
	Cowley											
3	Baird - Baird E	Bartlesville	1926	80		6,717						
4	Biddle	Stalnaker		600		24,846						
5		K C Lime										
6	Box	Mis L	1948	80		36,615						
7	Brown	Bartlesville	1922	80		3,428						
8	Burden	Bartlesville	1926	1,200		27,864						
9	Carson	Layton	1924	800	3,424,756	34,830						
10		Arbuckle										
11	Clarke	Bartlesville	1916	80	489,225	10,114						
12	Combs	Bartlesville	1947	240	229,711	78,713						
13	Couch	Burbank	1937	400	1,633,968	115,559						
14	Countryman	Layton	1936	600	155,440	12,330						
15	David - Davis S	Bartlesville	1935	900	1,063,418	56,940						
16	Deichman	Bartlesville	1941	400	744,140	77,237						
17	Eastman	Bartlesville	1924	1,200		40,763						
18	Falls City	Stalnaker	1916	600	1,260,827	5,609						
19	Frog Hollow	Bartlesville	1937	1,000	3,717,902	294,125						
20	Frog Hollow E	Bartlesville	1941	200	222,660	15,668						
21	Geuda Springs	Bartlesville	1936	600	496,990	23,122						
22		"Chat" Mbr.										
23	Gibson	Bartlesville	1941	220	324,352	35,306						
24	Graham	Layton	1924	800		31,820						
25		Arbuckle										
26	Grand Summit	Bronson	1926	400		7,650						
27	Henderson	Bronson	1942	160	123,217							
28		Arbuckle										
29	Hittle	Stalnaker	1926	1,000	8,491,949	327,391						
30		Arbuckle										
31	Murphy	Bartlesville	1933	600		83,791						
32	Rahn	Bartlesville	1939	880	1,512,912	131,128						
33	Rainbow Bend & Rainbow Bend N E & W	Burgess	1923	2,000	15,157,531	203,055						
34	Rock	Bartlesville	1923	700	2,644,745	193,558						
35	State	Layton	1926	1,500		24,506						
36		Arbuckle										
37	Thurlow	Arbuckle	1946	80		33,128						
38	Trees	Bartlesville	1934	300		13,321						
39	Turner	Layton	1937	240	265,207	7,039						
40	Weatherred	Stalnaker	1935	1,000	2,604,347	47,856						
41		Lansing - K C										
42		Mis L										
43		Arbuckle										
44	Winfield	Peacock Sand	1914	3,000		84,217						
45		Layton										
46		Bartlesville										
47		Arbuckle										
48	Cowley County Misc.					48,892						
	Dickenson											
49	Lost Springs N	"Chat" Mbr.	1945									
	Elk											
50	Bush - Denton	Stalnaker	1921	900		30,448						
51		Burgess										
52	Collyer	Ft Scott L	1924	300		11,127						
53	Dunkelberger	Bronson	1920	600		29,612						
54		Mis L										
55	Moline	Excell	1920	5,000		2,187						
56		Mis L										
57	Porter	Bronson	1923	360		4,800						
58		Arbuckle										
59	Schrader	K C Lime	1947	40		25,446						
60	Severy	Bronson	1922	2,000		8,276						
61	Webb	Excell	1924	3,600		42,323						
62		Red										
63		Ft Scott L										
64		Arbuckle										
65	Elk County Misc.					13,375						
	Greenwood											
66	Atyeo - Pixlee	Bartlesville	1923	1,000		466,421						
67	Beaumont		1920			48,531						
68	Bromagar	New Albany				5,779						
69	Browning	Bartlesville	1924	3,800		114,068						
70	Burkett	Bartlesville	1924	2,700		429,944						
71	Climax	"Chat" Mbr.				7,325						
72	De Malorie - Souder	Bartlesville	1924	4,500		162,596						
73	Dunaway	Mis L		1,000		79,753						
74	Eureka	Mis L	1920	1,200		102,872						
75	Funkhouser	Bartlesville	1926	2,500		240,966						
76	Gaffney	Bartlesville	1926	500	322,449	8,538						
77	Hamilton	Bartlesville	1929	3,000		411,531						
78	Lamont	Bartlesville	1927	2,600		138,205						
79	Madison	Bartlesville	1921	3,000		73,774						
80	Polhamus	Bartlesville	1922	1,400	2,423,033	41,328						
81	Quincy	Bartlesville	1926	3,600		140,635						

LINE NUMBER	NUMBER OF WELLS[d]			WELLS PRODUCING[f] DEC. 1949			RESERVOIR PRESSURE LB PER SQ INCH		SECONDARY RECOVERY[g]	CHARACTER OF OIL[h]		PRODUCING FORMATION					DEEPEST ZONE TESTED[n] TO END OF 1949	
	COMPLETED TO END 1949	1949		OIL		GAS	INITIAL	AVG./END 1949		GRAVITY A.P.I.	SULPHUR PER CENT	CHARACTER[i]	POROSITY PER CENT[j]	DEPTH TO TOP OF PRODUCING ZONE FT[k]	PROD. THICKNESS AVG. FT - NET	STRUCTURE[m]	NAME	DEPTH OF HOLE, FT
		COMPLETED	ABANDONED	FLOWING	ARTIFICIAL LIFT													
1	21		1		20							S		1,138	12			
2												Ch		1,622	16			
3	4		1		3							S		3,260	7			
4	21				21					39		S		2,300	20			
5												L		2,600	10			
6	6	1			6							L		2,850	15			
7	3		1		2							S			20			
8	38				30							S		2,865	35			
9	26				15							S		2,600				
10												D		3,450				
11	5				5					38		S		2,840	20			
12	17				17					40		S		2,833	20			
13	45				45					41		S		2,835	15			
14	17		2		9					34		S		1,950	12			
15	35		1		31							S		2,935	40			
16	22				22							S		2,835	35			
17	48				25					36		S		2,770	20			
18	24				8							S		2,000	12			
19	50	2			50							S		3,089	20			
20	7		1		6							S		3,060	8			
21	12				12							S		3,150	25			
22												Ch		3,320	7			
23	14				12					35		S		3,360	14			
24	33	3			12					39		S		2,550	15			
25												D		3,500	5			
26	12				10							L		1,913	19			
27	7				6							L		2,694	9			
28												D		3,419	4			
29	81				47					39		S		2,400	20			
30												D		3,280	8			
31	32				30				x			S		3,300	10			
32	45		1		44					40		S		2,915	30			
33	140		1		106							S		3,200	50			
34	65	6			65					38		S		2,760	30			
35	110		1		13							S		2,300	12			
36												D		3,500	5			
37	3	2			3							D		3,495	5			
38	10				10					38		S		2,975	25			
39	6				4							S		2,332	15			
40	41		1		19					38		S		2,300	15			
41												L		2,455	12			
42												L		3,065	8			
43												D		3,400	5			
44			1		67					38		S		1,400	15			
45												S		2,300	20			
46												S		3,050	12			
47												D		3,300	5			
48		4			53													
49										37		Ch		2,275	33			
50												S		1,060	10			
51												Ce		2,297	5			
52												L		1,518	10			
53												L		1,350	10			
54												L		1,970	39			
55												S		1,150	12			
56												L		1,940	18			
57										41		L		2,045	10			
58												D			4			
59										33		L		1,665	22			
60												L		1,159	13			
61												S		1,100				
62												S		1,350				
63												L		1,650				
64												D		2,286				
65	23		1		22													
66	93				93				x			S		2,327	50			
67	28				28													
68	24				24				x			S		427	11			
69	90				90				x			S		2,314	76			
70	101				101				x	38		S		2,000	100			
71	5				5							Ch		1,800	15			
72	129	3			129				x c			S		2,150	55			
73	53	5			48							L		1,800	12			
74	36	19			36							L		2,000	10			
75	57				57				x			S		1,750	45			
76	3				3							S						
77	86	3			86				x			S		1,766	72			
78	109				109				x	40		S		1,650	55			
79	106		1		105				x			S		1,800	60			
80	47		1		46				x	38		S		2,170	48			
81	114	5			114				x			S		1,420	52			

TABLE 1A - Continued OIL AND GAS PRODUCTION STATISTICS FOR EASTERN KANSAS

LINE NUMBER	FIELD (County)[a]	PRODUCING FORMATION NAME AND AGE[b]	YEAR OF DISCOVERY	OIL PRODUCTION AREA PROVED ACRES	OIL PRODUCTION BARRELS TO END OF 1949	OIL PRODUCTION BARRELS DURING 1949	GAS PRODUCTION AREA PROVED ACRES	GAS PRODUCTION THOUSAND CU FT[c] TO END OF 1949	GAS PRODUCTION THOUSAND CU FT[c] DURING 1949	GAS/OIL RATIO[d] MCF/BBL	CONDENSATE PRODUCTION Thousands of Bbl TO END OF 1949	CONDENSATE PRODUCTION Thousands of Bbl DURING 1949
82	Reece	Mrs L		1,500		48,294						
83	Sallyards	Bartlesville	1921	8,000		435,686						
84	Scott	Bartlesville	1925	2,500		71,823						
85	Seeley - Wick	Bartlesville	1922	7,000		1,521,834						
86	Stanhope	Mrs L	1949	160		9,423						
87	Teeter	Bartlesville	1922	4,000		209,872						
88	Teichgraber	Bartlesville		900		12,949						
89	Thrall - Agurd	Bartlesville	1921	7,000		681,051						
90	Virgil	Bartlesville	1916	4,800		153,188						
91		Burgess										
92		Mrs L										
93	Virgil N	Bartlesville		8,000		347,000						
94		Mrs L										
95	Wiggins	Bartlesville	1925	2,500		26,140						
96	Wilkerson	Bartlesville		1,300		13,238						
97	Willard					24,139						
98	Greenwood County Misc.					21,409						
	Lyon											
99	Rock Creek	Bartlesville	1947	160	14,942	4,390						
	Woodson											
100	Big Sandy	Burbank	1926	800		26,727						
101	Hoagland	Mrs L	1925	700		10,594						
102	Winterscheid	Bartlesville		7,700		344,736						
103		Mrs L										
104	Woodson County Misc.					5,287						
105	Eastern Kansas Misc.					3,887,868						

Natural Gas production for 1949, from miscellaneous fields, was 2,872,000 Mcf, measured on two lb pressure base.

of completions of wildcats in Kansas for the year 1949 were as follows: Barton, 57; Rooks, 56; Ellis, 48; Stafford, 41; Butler, 39; Rice, 28; and Russell, 24.

Of the more active counties (those with more than 30 wildcat locations), the following data show the percentage successful in order: Russell, 25; Stafford, 25; Butler, Rice, Barton, and Ellis counties from 17.9 to 16.6; and Rooks with 12.4.

Although Rooks County has been one of the more active counties for the past several years, it has the highest dry hole ratio and one of the lowest percentages of successful wildcats in the state. The reason for its continued activity lies in the fact that higher initial potentials have been obtained in most discoveries, which somewhat compensates for its lower success ratio.

GEOPHYSICAL ACTIVITY

In Kansas during 1949, there was approximately a one-third reduction in the number of geophysical and core drill parties in comparison with 1948. At the end of 1949, there was one gravity meter crew at work in Ness County, seven seismograph crews scattered from Sumner County to Sheridan County, seven core drill crews at work from Hamilton County to Wabaunsee County, and 17 crews doing surface work in Wabaunsee County.

Table 2 is a summary of drilling operations in Kansas in which the oil and gas pool discoveries are listed first, followed by the important exploratory dry holes, all listed in order by townships south. Since the naming of these pools, the Bartholomew North Pool has been combined with the Bartholomew, the Black Cloud Pool has been combined with the Workman S. E., and subsequently the Workman S. E. Pool combined with the Bryant as Bryant. The Gates South Pool is a revival of a previously existent pool, and the Proffitt Pool is a new pool given a discontinued pool name.

Wabaunsee County

Probably the outstanding exploratory development in Kansas during 1949 was the discovery of the Davis Ranch Pool by the Carter Oil Co. The discovery well, located in the SW SE SW of Section 33 - T13S - R10E, was completed with a physical potential of 2,580 B/D from the Viola lime at 3,201 to 3,206 ft. Since the original completion, eight producers have been added to the pool, seven of which are maximum wells (3,000 B/D). Aladdin Petroleum Corp. and W. E. Bakke are currently giving the pool a one-half mile east extension with their No. 1 Schutter in the SW SW SW of Section 34 - T13S - R10E.

Barber County

Another outstanding discovery was made in October by

LINE NUMBER	NUMBER OF WELLS[c] COMPLETED TO END 1949	1949 COMPLETED	1949 ABANDONED	WELLS PRODUCING[f] DEC. 1949 OIL FLOWING	OIL ARTIFICIAL LIFT	GAS	RESERVOIR PRESSURE LB. PER SQ. INCH INITIAL	AVG./END 1949	SECONDARY RECOVERY[g]	CHARACTER OF OIL[h] GRAVITY A.P.I.	SULPHUR PER CENT	PRODUCING FORMATION CHARACTER[i]	POROSITY PER CENT[j]	DEPTH TO TOP OF PRODUCING ZONE FT.[k]	PROD. THICKNESS AVG. FT. / NET	STRUCTURE[m]	DEEPEST ZONE TESTED[n] TO END OF 1949 NAME	DEPTH OF HOLE, FT.
82	31	12			31							L		2,100	12			
83	132				132				W			S		2,350	150			
84	66				66				W			S		2,525	75			
85	334	8			334				W			S		1,930	45			
86	7	5			7							L		2,425	11			
87	183		4		179				W			S		2,400	150			
88	17				17							S		2,450	50			
89	253	2			253				W			S		2,190	166			
90	136	6			136					38		S		1,550	40			
91												C g		1,700	10			
92												L		1,700	12			
93	322	3			322					38		S		1,550	52			
94												L		1,700	12			
95	41				41							S		1,860	15			
96	13				13							S		2,300	48			
97	8	4			8									1,875	10			
98	35	2			35													
99										38		S		1,930	12			
100	19				19							S		1,200	50			
101	18				18							L		1,620	37			
102	282	58			282					39		S		1,575	15			
103												L		1,625				
104	10		1		9													

the Barbara Oil Co. seven miles east of the Boggs Pool. The discovery was Barbara Oil Co.'s No. 1 Page Estate "A", located in the SW SW SW of Section 15 - T33S - R11W and was completed with a physical potential of 146 B/D from the Mississippi lime. Since the drilling of the discovery well, Barbara Oil Co. has added three producers and is drilling a fourth test. One of the three producers was finaled with a bottom hole bomb potential of 11,392 B/D.

Phillips County

The Hufstutter Pool was not particularly large or spectacular, but is significant inasmuch as it represents the most northwestard production in Kansas. Located seven miles from the Nebraska line in Phillips County, in Section six - T2S - R18W, it was drilled by the B. and R. Drilling Co. and L. B. Stableford. Initial production amounted to 58 B/D at 3,444 ft in the Kansas City lime. The area has nine productive wells at the present time.

Rooks County

One of the most active areas in the state during the past year was the Berland Pool. At the end of 1948, there were nine producing wells in the pool. By the end of 1949, 49 producing wells had been added to this pool, extending it two miles north and one-half mile to the east and west. The pool now lists 57 Arbuckle lime wells and one Lansing lime well with a combined daily potential of 57,563 bbl of oil.

LEASING ACTIVITY

The following tabulation sets out the acreage leased in various areas of Kansas during 1949.

Total acreage purchased in N. E. Kansas	708,649
Total acreage purchased on Central Kansas Uplift	73,506
Total acreage purchased in Western Kansas	305,397
Total acreage purchased in Kansas for 1949 (exclusive of routine leasing)	1,087,552
Total acreage purchased in Kansas for 1948 (exclusive of routine leasing)	725,716

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TABLE 1B - OIL AND GAS PRODUCTION STATISTICS FOR WESTERN KANSAS IN 1949

LINE NUMBER	FIELD (County)[a]	PRODUCING FORMATION NAME AND AGE[b]	YEAR OF DISCOVERY	OIL PRODUCTION			GAS PRODUCTION			GAS/OIL RATIO[c] MCF/BBL	CONDENSATE PRODUCTION Thousands of Bbl	
				AREA PROVED ACRES	BARRELS TO END OF 1949	BARRELS DURING 1949	AREA PROVED ACRES	THOUSAND CU FT[c] TO END OF 1949	THOUSAND CU FT[c] DURING 1949		TO END OF 1949	DURING 1949
	Barber											
1	Boggs	Simpson, Ord	1946	1,160	755,407	260,973						
2	Deerhead	Vio, Simpson, Ord	1943	520	450,422	93,008						
3	Digner	Vio, Simpson, Ord	1948	600	442,159	307,419						
4	Lake City	Arb, Ord	1937	200	274,813	24,432						
5	Marjorie	Arb, Ord	1945	900	1,249,465	312,272						
6	Skinner	Maxsner, Vio, Ord	1943									
7	Rhodes	Mis, Mis U	1949	160	8,163	8,163						
8	Sun City	Lan K C, Pen	1941	400	1,320,778	81,913						
9	Turkey Creek	Pen Sd, Pen	1943	60	23,934	2,497						
10	Whelan	Mis, Mis U	1934	960	2,050,967	153,330						
11	Aetna	Mis, Mis U	1935				160	560,061	57,244			
12	Deerhead	Vio, Ord	1942				1,200	1,693,763				
13	Donald	Mis, Mis U	1946				x	x	x			
14	Medicine Lodge	Mis, Mis U	1927		45,703		6,000	96,316,386	4,818,818			
15	Skinner	Vio, Ord	1944				2,160	19,201,788	1,937,063			
16	Whelan	Mis, Mis U	1934				640	19,172,192	2,905,786			
	Barton											
17	Ainsworth, S. E.	Arb, Ord	1943	Combined with Trapp Pool								
18	Albert	Reagan, Cam, Lan K C, Pen	1935	Combined with Otis - Albert Pool								
19	Ames	Arb, Ord	1943	680	853,849	141,480						
20	Ames, N. W.	Arb, Ord	1947	80	7,917	1,598						
21	Ash Creek	Arb, Ord	1947	1,170	556,148	236,669						
22	Axson	Arb, Ord	1949	80	2,863	2,863						
23	Bahr	Reagan, Cam	1943	Abd.								
24	Barrett	Arb, Ord, Cmeal, Pen	1943	120	96,535	8,759						
25	Beaver	Arb, Ord, Reagan, Ord	1934	1,740	2,665,222	364,739						
26	Beaver, N. W.	Lan K C, Pen	1942	600	325,396	162,105						
27	Beaver, N.	Arb, Ord, Shawnee, Pen	1937	320	489,314	64,835						
28	Beaver, (Shallow)	Lan K C, Pen	1939	440	589,234	106,722						
29	Beaver, S.	Arb, Ord	1945	120	47,130	5,979						
30	Behrens	Arb, Ord	1945	840	383,769	78,666						
31	Bergtal	Arb, Ord	1947	40	1,631	300	x	403,161	403,161			
32	Bird	Reagan, Cam, Lan K C, Pen	1940	Combined with Otis - Albert Pool								
33	Bloomer	Arb, Ord	1936	5,620	33,041,568	2,511,351						
34	Boyd	Arb, Ord	1939	1,170	1,849,002	341,582						
35	Breford, S. W.	Arb, Ord	1942	40	25,777	2,255						
36	Bryant	Arb, Ord	1948	480	88,012	83,963						
37	Bryant, S. E.	Arb, Ord	1949	360	52,791	52,791						
38	Buckbee	Arb, Ord	1949	40								
39	Carroll	Arb, Ord, Lan K C, Pen	1945	1,080	914,690	291,926						
40	Carroll, S. W.	Lan K C, Pen	1947	160	26,056	10,822						
41	Cheyenne View	Arb, Ord	1949	40	443	443						
42	Cheyenne View, S. W.	Arb, Ord	1949	40	469	469						
43	Davidson	Sooy, Pen, Arb, Ord	1928	400	372,235	16,735						
44	Dundee	Arb, Ord	1945	40	7,553	2,591	x	479,458	380,545			
45	Eberhardt	Arb, Ord	1935	320	375,242	19,282	x	303,726	9,444			
46	Ellinwood, N.	Arb, Ord	1937	40	77,708	3,761						
47	Enfeld	Arb, Ord	1947	40	5,343	1,934						
48	Everleigh	Lan K C, Pen, Arb, Ord Pre-Cam	1943	990	726,535	262,959						
49	Feltes, N. W.	Arb, Ord	1945	310	241,033	51,669						
50	Franzen	Lan K C, Pen	1948	40	295	295						
51	Hagen	Arb, Ord	1938	160	331,191	32,338						
52	Hamer	Arb, Ord	1940	220	294,749	57,539						
53	Hamer, N.	Arb, Ord, Lan K C, Pen	1949	400	95,803	95,803						
54	Heizer	Lan K C, Pen	1935	40	40,157	2,666						
55	Hiss	Lan K C, Pen	1936	800	1,102,282	125,533						
56	Hiss, S. E.	Arb, Ord	1948	280	27,203	26,616						
57	Hoisington	Arb, Ord	1938	960	885,594	235,382						
58	Homestead	Arb, Ord	1948	40	7,464	3,366						
59	Klug	Arb, Ord	1946	80	28,395	5,181						
60	Klug, N.	Arb, Ord	1948	80	30,048	19,373						
61	Kowalsky "A"	Arb, Ord	1947	280	135,181	45,219						
62	Kowalsky, N. W.	Arb, Ord	1948	400	141,460	82,197						
63	Kraft - Prusa	Shawnee, Pen, Lan K C Pen, Sooy Sd, Pen	1937	21,210	43,543,400	5,454,507						
64	Kraft - Prusa, N. E.	Arb, Ord		280	211,185	44,394						
65	Kraft - Prusa, S.	Reagan, Cam		80	51,424	4,389						
66	Lake Barton	Arb, Ord	1948	120	4,276	3,817						
67	Lanterman	Arb, Ord	1935	500	819,026	20,076						
68	Laudick	Arb, Ord	1948	360	104,304	74,688						
69	Mc Cauley	Lan K C, Pen	1949	40	3,636	3,636						
70	Meadowside	Lan K C, Pen	1949	160	16,590	16,590						
71	Merten	Lan K C, Arb, Reagan, Cam	1942	Combined with Otis - Albert Pool								

LINE NUMBER	NUMBER OF WELLS[e]			WELLS PRODUCING[f] DEC. 1949			RESERVOIR PRESSURE LB PER SQ INCH		SECONDARY RECOVERY[g]	CHARACTER OF OIL[h]		PRODUCING FORMATION					DEEPEST ZONE TESTED[n] TO END OF 1949	
	COMPLETED TO END 1949	1949		OIL		GAS	INITIAL	AVG./END 1949		GRAVITY A.P.I.	SULPHUR PER CENT	CHARACTER[i]	POROSITY PER CENT[j]	DEPTH TO TOP OF PRODUCING ZONE FT[k]	PROD. THICKNESS AVG. FT / NET	STRUCTURE[R]	NAME	DEPTH OF HOLE, FT
		COMPLETED	ABANDONED	FLOWING	ARTIFICIAL LIFT													
1	25	4		11	18		1,856	1,638		26.4	x	S	14.3	4,844	6	N	Arbuckle	5,068
2	14		1		13		x	x		43.0	x	L S	x	4,950	4	x	x	x
3	11	4			15		x	x		40.8	x	L S	x	5,239	10	x	x	x
4	4				4		x	x		43.0	x	D	x	4,607	18	x	x	x
5							x	x		38.8	x	D	x	4,407	4	x	x	x
6	60	1			58		x	x		30.0	x	S L	x	4,845	15	x	x	x
7		4			4		x	x		26.3	x	L	x	4,475	15	x	x	x
8	11				11		x	x		31.4	x	L	x	4,344	x	x	x	x
9	1				1		x	x		x	x	S	x	4,430	26	x	x	x
10	22		1		21		x	x		31.0	x	L	x	4,355	27	x	x	x
11	x	x	x			x	x	x				L	x	4,810	14	x	x	x
12	x	x	x			x	x	x				L	x	4,931	9	x	x	x
13	x	x	x			x	x	x				L	x	5,167	8	x	x	x
14	x	x	x			x	x	x		x	x	L	x	4,500	18	x	x	x
15	x	x	x			x	x	x				L	x	4,400	30	x	x	x
16	x	x	x			x	x	x				L	x	4,350	20	x	x	x
17							x	x		x	x	D	x	3,358	3	x	x	x
18							x	x		35.0	x	S L	x	3,600-3,040	3-10	x	x	x
19	26				26		x	x		46.0	x	D	x	3,325	10	x	x	x
20	2				2		x	x		40.2	x	D	x	3,312	6	x	x	x
21	28	11			39		x	x		28.7	x	D	x	3,787	9	x	x	x
22		2			2		x	x		43.0	x	D	x	3,400	11	x	x	x
23							x	x		37.3	x	S	x	x	x	x	x	x
24	3				3		x	x		x	x	D L	x	3,350-2,885	3-5	x	x	x
25	45	13			58		x	x		39.0	x	S D	x	3,335	2	x	x	x
26	10	5			15		x	x		38.0	x	L	x	3,665	12	x	x	x
27	6	2			8		x	x		39.0	x	D L	x	3,316-2,875	10-5	x	x	x
28	11				11		x	x		36.0	x	L	x	3,060	10	x	x	x
29	3				3		x	x		42.0	x	D	x	3,359	x	x	x	x
30	19	2			21		x	x		38.6	x	L	x	3,659	4	x	x	x
31	1				1	x	x	x		x	x	D	x	3,852	20	x	x	x
32							x	x		x	x	S L	x	3,500-3,045	12-17	x	x	x
33	290	4			281		x	x		42.6	x	D	x	3,255	8	x	x	x
34	34	5			39		x	x		37.4	x	D	x	3,440	12	x	x	x
35	1				1		x	x		42.0	x	D	x	3,300	3	x	x	x
36	3	13			16					x	x	D	x	3,392	30	x	x	x
37		9			9					40.2	x	D	x	3,377	4	x	x	x
38		1			1					x	x	D	x	3,352	8	x	x	x
39	31	5			36					39.0	x	D L	x	3,355-3,016	16-4	x	x	x
40	2	2			4					36.0	x	L	x	3,193	8	x	x	x
41		1			1					40.0	x	D	x	3,376	17	x	x	x
42		1			1					40.0	x	D	x	3,165	9	x	x	x
43	11		5		6					38.0	x	C g D	x	3,317-3,314	10-9	x	x	x
44	1				1	x				x	x	D	x	3,507	x	x	x	x
45	8				8	x				38.0	x	D	x	3,311	3	x	x	x
46	1				1					40.0	x	D	x	3,325-3,340	8-9	x	x	x
47	1				1					43.0	x	D	x	3,343	15	x	x	x
48	20	13			33					36.0	x	L D	x	3,137-3,311	34-21	x	x	x
49	8		1		6					40.0	x	D	x	x-3,342	x-3	x	x	x
50		1			1					x	x	L	x	3,174	12	x	x	x
51	4		4		4					39.0	x	L	x	3,323	4	x	x	x
52	9	2			11					41.0	x	D	x	3,350	8	x	x	x
53		19			19					38.0	x	L	x	3,351	16	x	x	x
54	1				1					38.9	x	L	x	3,228	2	x	x	x
55	18		1		17					34.0	x	L	x	3,270-3,220	5-8	x	x	x
56	1	6			7					36.5	x	D	x	3,545	16	x	x	x
57	31	1			32					37.5	x	D	x	3,440	4	x	x	x
58	1				1					37.0	x	D	x	x	x	x	x	x
59	2				2					28.0	x	D	x	3,414	7	x	x	x
60	2				2					37.0	x	D	x	3,398	10	x	x	x
61	7				7					49.5	x	D	x	3,369	4	x	x	x
62	9	1			10					x	x	D	x	3,374	13	x	x	x
63	573	33			606					38.0	x	L	x	1,160	175	x	x	x
64	3	4			7							C g D	x	3,335	6	x	x	x
65	2				2							S	x	3,280	8	x	x	x
66	1	2			3					32.3	x	D	x	3,310	8	x	x	x
67	11		1		8					35.0	x	D	x	3,366	7	x	x	x
68	5	4			9					39.0	x	D	x	3,333-3,550	3-3	x	x	x
69		1			1					37.0	x	L	x	3,364	6	x	x	x
70		4			4					38.9	x	L	x	3,276	4	x	x	x
71										35.0	x	L	x	3,068	12	x	x	x
												D	x	3,294	40			
												S	x	3,572	60	x	x	x
														3,550	6			

TABLE 1B - Continued OIL AND GAS PRODUCTION STATISTICS FOR WESTERN KANSAS

LINE NUMBER	FIELD (County)[a]	PRODUCING FORMATION NAME AND AGE[b]	YEAR OF DISCOVERY	OIL PRODUCTION			GAS PRODUCTION			GAS/OIL RATIO[d] MCF/BBL	CONDENSATE PRODUCTION Thousands of Bbl	
				AREA PROVED ACRES	BARRELS TO END OF 1949	BARRELS DURING 1949	AREA PROVED ACRES	THOUSAND CU FT[c] TO END OF 1949	THOUSAND CU FT[c] DURING 1949		TO END OF 1949	DURING 1949
72	Morten, N. E.	Arb, Ord	1945	40	12,727	1,621						
73	Morten, S. E.	Reagan, Cam	1949	40	5,962	5,962						
74	Mue Tan	Arb, Ord	1942	40	Abd.							
75	Odin	Arb, Ord	1941	40	Abd.							
76	Pawnee Rock, E.	Arb, Ord	1941	40	20,847	2,330						
77	Pritchard	Lan K C, Pen, Arb, Ord	1944	770	742,509	128,470						
78	Reif	Lan K C, Pen, Arb, Ord	1944	100	Combined with Trapp Pool							
79	Rice	Arb, Ord	1936	480	821,332	52,420	x	33,873				
80	Roesler	Arb, Ord	1943	40	32,051	4,123						
81	Rolling Green	Lan K C, Pen	1948	120	12,305	5,271						
82	Rolling Green, E.	Arb, Ord	1949	80	1,777	1,777						
83	Rowland	Arb, Ord	1949	80	1,607	1,607						
84	Salica	Lan K C, Pen, Arb, Ord	1931		87,848,203	5,720,310	x	326,849				
85	St. Peter	Arb, Ord	1944	80	74,804	13,825						
86	Sunny Valley	Lan K C, Pen, Arb, Ord	1949	330	79,765	79,765						
87	Unruh	Arb, Ord	1945	360	82,350	23,613	x	8,201,702	1,725,608			
88	Workman	Arb, Ord	1944	600	226,480	111,218						
89	Workman, S. E.	Arb, Ord	1949	40								
	Dickinson											
90	Bonaccord	Burgess Sd, Pen	1948	80	29,161	1,635						
	Edwards											
91	Belpre	Lan, Pen	1942	640	x	x	x	5,692,177	903,166			
92	Bradbridge	Lan K C, Pen	1949	x	x	x	x	x	x			
	Ellis											
93	Antonio	Arb, Ord	1947	160	50,940	18,285						
94	Antonio Townsite	Arb, Ord	1949	40	805	805						
95	Breeding	Lan K C, Pen	1943	240	195,508	14,102						
96	Bemis - Schutts	Arb, Ord	1935	18,400	59,447,412	4,651,115						
97	Bemis, South	Arb, Ord	1938	Combined with Bemis - Schutts Pool								
98	Blue Hill	Topeka, Lan K C, Arb, Ord	1937	880	1,575,784	166,110						
99	Burnett	Lan K C, Pen, Arb, Ord	1937	6,575	34,450,618	2,736,656						
100	Burnett, South	Arb, Ord	1947									
101	Burnett, N. W.	Lan K C, Pen, Arb, Ord	1947	800	1,365,319	373,347						
102	Burnett, S. W.	Lan K C, Arb, Ord	1946	1,750	1,559,697	760,039						
103	Canyons	Arb, Ord	1948	40	6,259	1,813						
104	Catherine	Lan K C, Pen	1936	200	180,946	23,329						
105	Catherine, E.	Arb, Ord	1948	200	17,658	17,658						
106	Catherine, N. W.	Arb, Ord	1944	340	290,695	70,692						
107	Catherine, South	Arb, Ord	1946	680	428,781	132,608						
108	Catherine Townsite	Arb, Ord	1949	40								
109	Chrisler	Lan K C, Pen	1949	40	5,977	5,977						
110	Dreiling	Arb, Ord	1949	80	6,123	6,123						
111	Ellis	Arb, Ord	1942	800	907,167	104,113						
112	Emmrich	Lan K C, Pen	1937	200	218,150	13,003						
113	Emmrich, N. E.	Arb, Ord	1949	40	2,353	2,353						
114	Haller	Topeka, Pen	1936	40	24,463	620						
115	Herzog	Arb, Ord	1940	500	793,475	116,900						
116	Irvin	Arb, Ord	1946	320	215,305	74,557						
117	Koblitz	Arb, Ord	1937	560	774,547	93,875						
118	Kraus	Susy, Pen	1936	160	112,787	13,575						
119	Leiker	Arb, Ord	1943	160	87,483	12,187						
120	Madden	Arb, Ord	1948	480	181,051	113,378						
121	Meistrell	Arb, Ord	1949	120	24,857	24,857						
122	Nicholson	Arb, Ord	1945	160	191,897	39,873						
123	Penny Wann	Reagan, Cam	1936	100	141,870	7,679						
124	Pleasant	Arb, Ord	1944	750	734,836	137,655						
125	Pleasant, North	Arb, Ord	1946	40	2,168	1,044						
126	Polifka	Arb, Ord	1948	40	11,688	10,787						
127	Reed	Lan K C, Pen	1949	40	1,508	1,508						
128	Richards	Lan K C, Pen	1938	Abd.								
129	Riverview	Arb, Ord, Lan K C, Pen	1943	840	1,247,643	172,439						
130	Riverview, S. E.	Arb, Ord	1945	Abd.								
131	Ruder	Arb, Ord	1935	800	1,019,219	31,600						
132	Schmeidler	Arb, Ord	1944	270	241,043	60,443						
133	Schoettchen	Arb, Ord	1946	200	217,981	76,615						
134	Solomon	Arb, Ord	1936	160	114,384	x						
135	Solomon, N. E.	Arb, Ord	1947	200	65,263	33,139						
136	Sugarloaf	Arb, Ord	1941	120	216,362	22,718						
137	Sugarloaf, S. E.	Lan K C, Pen Lan K C, Pen	1941	60	95,016	13,762						
138	Toulon	Arb, Ord	1935	240	409,164	31,067						
139	Ubert	Arb, Ord	1936	160	263,685	11,905						
140	Walters	Shawnee, Pen, Arb, Ord	1936	1,700	4,631,830	379,538						
141	Warren	Lan K C, Pen	1949	40	6,166	6,166						
142	Weigle	Arb, Ord	1948	40	1,171							
143	Wheatland	Arb, Ord	1949	40								
144	Younger	Arb, Ord	1944	180	136,070	25,489						
145	Younger, North	Arb, Ord	1947	80	12,445	5,844						
	Ellsworth											
146	Ibaben [1]	Arb, Ord	1930	160	46,850	565						

LINE NUMBER	NUMBER OF WELLS[a]			WELLS PRODUCING[f] DEC. 1949			RESERVOIR PRESSURE LB PER SQ INCH		SECONDARY RECOVERY[g]	CHARACTER OF OIL[h]		PRODUCING FORMATION					DEEPEST ZONE TESTED[m] TO END OF 1949	
	COMPLETED TO END 1949	1949		OIL		GAS	INITIAL	AVG./END 1949		GRAVITY A.P.I.	SULPHUR PER CENT	CHARACTER[i]	POROSITY PER CENT[j]	DEPTH TO TOP OF PRODUCING ZONE FT.[k]	PROD. THICKNESS AVG. FT. / NET	STRUCTURE[l]	NAME	DEPTH OF HOLE, FT.
		COMPLETED	ABANDONED	FLOWING	ARTIFICIAL LIFT													
72	1				1					35.0	x	D	x	3,494	3	x	x	x
73		1			1					35.0	x	S	x	3,567	1	x	x	x
74										40.0	x	D	x	3,312	10	x	x	x
75										x	x	D	x	3,340	2	x	x	x
76	1				1					38.1	x	D	x	3,812	7	x	x	x
77	18		3		15					35.2	x	L D	x	3,540-3,253	3-8	x	x	x
78	4									35.0	x	L D	x	3,400-3,105	4-10	x	x	x
79	11	1			12	x				41.0	x	D	x	3,350	5	x	x	x
80	1		1		1					x	x	D	x	3,291	7	x	x	x
81	3				3					39.0	x	L	x	3,257	6	x	x	x
82		2			2					x	x	D	x	3,509	6	x	x	x
83		2			2					39.5	x	D	x	3,323	24	x	x	x
84	744	42			786	x				42.5	x	L D	x			x	x	x
85	2				2					39.0	x	D	x	3,387	3	x	x	x
86		11			11					43.0	x	L D	x	3,208-3,423	9-10	x	x	x
87	9		3		6	x				34.0	x	D	x	3,365	3	x	x	x
88	1	19			20					38.8	x	D	x	3,408	3	x	x	x
89		1			1					x	x	D	x	x	x	x	x	x
90	2				2					x	x	S	x	2,483	2	x	x	x
91	x	x	x			x				x	x	L	x	x	x	x	x	x
92	x	x	x			x				x	x	L	x	x	x	x	x	x
93	3	1			4					35.0	x	D	x	3,712	5	x	x	x
94		1			1					x	x	D	x	3,697	6	x	x	x
95	6				6					x	x	L	x	3,150	4	x	x	x
96	532		1		525					34.6	x	D	x	3,380	11	x	x	x
97										31.0	x	D	x	3,592	11	x	x	x
98	22				22					33.0	x	L L D	x x	3030-3075 3,360	5-33 6	x x	x	x
99	267	8	1		263					30.0	x	L D	x	3,093	8	x	x	x
100										x	x	D	x	3,570	4	x	x	x
101	25	2			27					32.5	x	D	x	3,617	7	x	x	x
102	59	11			70					30.0	x	L D	x	3,207-3,633	50-4	x	x	x
103	1				1					x	x	D	x	3,643	47	x	x	x
104	1	4			5					28.0	x	L	x	3,262-3,390	24-13	x	x	x
105		5			5					x	x	D	x	3,516	26	x	x	x
106	9	2			11					x	x	D	x	3,575	21	x	x	x
107	17				17					32.0	x	D	x	3,555	8	x	x	x
108		1			1					x	x	D	x	3,585	18	x	x	x
109		1			1					x	x	L	x	3,426	35	x	x	x
110		2			2					31.7	x	D	x	3,367	16	x	x	x
111	15				15					36.0	x	D	x	3,832	8	x	x	x
112	5				5					38.5	x	L	x	3,262	7	x	x	x
113		1			1					x	x	D	x	3,541	3	x	x	x
114	1				1					29.0	x	L	x	3,045	9	x	x	x
115	14				13					37.5	x	D	x	3,450	8	x	x	x
116	8				8					37.0	x	D	x	3,852	x	x	x	x
117	11	3			14					26.0	x	D	x	3,694	4	x	x	x
118	3				3					39.0	x	C g	x	3,735	5	x	x	x
119	2				2					39.8	x	D	x	3,578	5	x	x	x
120	6	6			12					39.0	x	D	x	3,569	5	x	x	x
121		3			3					x	x	D	x	3,532	4	x	x	x
122	6				6					34.0	x	D	x	3,843	12	x	x	x
123	3		1		2					26.9	x	S	x	3,653	3	x	x	x
124	18		1		17					37.6	x	D	x	3,850	4	x	x	x
125	2		1		1					47.6	x	D	x	3,790	x	x	x	x
126	1				1					31.0	x	D	x	3,639	33	x	x	x
127		1			1					x	x	L	x	3,424	12	x	x	x
128										27.5	x		x			x	x	x
129	18	4			22					27.5	x	D L	x	3,422	18	x	x	x
130										x	x		x			x	x	x
131	9	1			5					35.0	x	x	x	3,572	10	x	x	x
132	9				9					26.0	x	D	x	3,625	10	x	x	x
133	7	2			9					31.0	x	D	x	3,560	9	x	x	x
134	2		2		2					21.0	x	D	x	3,630	3	x	x	x
135	3	3			6					19.5	x	D	x	3,639	4	x	x	x
136	2	1			3					32.0	x	D	x	3,645	9	x	x	x
137	3				3					x	x	L	x	3,312	8	x	x	x
											x	L	x	3,300	5	x		
138	7				7					34.0	x	D	x	3,512	45	x	x	x
139	3				3					32.0	x	D	x	3,707	7	x	x	x
140	50	2			52					28.5	x	L D	x	3,160-3,619	5-8	x	x	x
141		1			1					x	x	L	x	x	x	x	x	x
142	1				1					34.0	x	D	x	3,633	2	x	x	x
143		1			1					x	x	D	x	x	x	x	x	x
144	5				5					33.5	x	D	x	3,540	45	x	x	x
145	2				2					x	x	D	x	3,580	18	x	x	x
146	2		2							40.0	x	D	x	3,269	2	x	x	x

TABLE 1B - Continued OIL AND GAS PRODUCTION STATISTICS FOR WESTERN KANSAS

LINE NUMBER	FIELD (County)[a]	PRODUCING FORMATION NAME AND AGE[b]	YEAR OF DISCOVERY	OIL PRODUCTION			GAS PRODUCTION			GAS/OIL RATIO[d] MCF/BBL	CONDENSATE PRODUCTION Thousands of Bbl	
				AREA PROVED ACRES	BARRELS TO END OF 1949	BARRELS DURING 1949	AREA PROVED ACRES	THOUSAND CU FT[c] TO END OF 1949	THOUSAND CU FT[c] DURING 1949		TO END OF 1949	DURING 1949
147	Hriken, North	Arb, Ord	1942	120	152,615	13,547						
148	Lorraine	Lan K C, Pen, Arb, Ord	1934	6,000	10,149,789	153,035						
149	Palacky	Lan K C, Pen, Arb, Ord	1949	80	5,326	5,326						
150	Stoltenberg	Arb, Ord	1931	10,880	29,654,796	2,114,118	x	144,784	126,467			
151	Stoltenberg, S. W.	Arb, Ord	1940	Combined with Stoltenberg Pool								
152	Vacek	Arb, Ord	1944	100	53,611	10,749						
153	Wilkins, S. E.	Arb, Ord	1942	220	362,004	34,479						
	Finney											
154	Nunn	Lan K C, Pen, Mis, Mis U	1938	1,080	1,299,643	253,831						
	Graham											
155	Alda	Lan K C, Pen	1944	40	23,740	1,302						
156	Faulkner	Lan K C, Pen	1945	120	141,905	29,126						
157	Gettysburg	Lan K C, Pen	1941	80	43,011	8,114						
158	Houston	Lan K C, Pen	1947	Abd.								
159	Luck	Lan K C, Pen	1945	Abd.								
160	Morel	Arb, Ord	1938	5,880	8,813,894	1,393,238						
161	Morlan	Arb, Ord	1949	200	32,433	32,433						
162	Mullenberg	Arb, Ord	1949	80	3,725	3,725						
163	Penokee	Lan K C, Pen	1940	120	91,878	27,380						
164	Teall	Lan K C, Pen	1949	40	4,230	4,230						
	Harper											
165	Grubs	Mis, Mis U	1949	40	1,424	1,424						
	Harvey											
166	Halstead	Mis, Mis U	1929	1,350	1,819,708	41,657						
167	Hollow - Nikkel	Mis, Mis U, Hunton, Dev, Simpson, Ord	1931	1,500	20,462,813	130,932						
168	Jones	Mis, Mis U	1949				40	x	x			
169	Jones, N. E.	Mis, Mis U	1949				40	x	x			
170	Sperling	Hunton, Dev	1935	500	562,829	13,841						
		Mis, Mis U	1935				40	387,238	40,200			
171	Stucky	Mis, Mis U	1942	40	1,827	155	x	619,991	184,257			
	Kearney											
172	Patterson	Patterson Sd, Pen	1941	120	293,615	30,599						
	Kingman											
173	Cunningham	Lan K C, Pen	1931	1,600	6,905,735	298,869						
		Vio, Ord										
174	Pat Creek	Vio, Ord	1947	120	91,762	17,022						
175	Cunningham	Vio, Ord, Arb, Ord	1931				10,000	69,808,395	1,217,892			
	Kiowa											
176	Alford	Mis, Mis U	1944				160	x	x			
177	Brenham	Mis Lime	1947				160	x	x			
178	Excel	x	1948	40	16,580	12,463						
	Mc Pherson											
179	Battle Hill	Mis, Mis U	1945	20	33,555	5,282						
180	Battle Hill, North	Mis, Mis U	1948	80	22,287	11,860						
181	Battikofer, North	Mis, Mis U	1946	100	6,805	1,721						
182	Battikofer	Mis, Mis U	1940	880	194,702	8,468						
183	Bonaville	Simpson, Ord	1949	80	4,499	4,499						
184	Bornholdt	Mis, Mis U	1937	4,000	12,518,896	612,608						
185	Burk	Mis, Mis U	1948	200	41,741	20,766						
186	Canton, North	Mis, Mis U	1936	480	490,058	55,855						
187	Chandberg	Lan K C, Pen, Mis, Mis U	1929	740	1,703,955	22,833						
188	Crowther	Mis, Mis U, Misener, Ord	1942	1,540	2,378,693	258,745						
189	Georob	Mis Lime	1947	400	352,224	129,931						
190	Graber	Hunton, Dev	1934	3,000	9,113,878	257,477						
191	Gypsum Creek	Mis, Mis U	1944	540	266,987	47,324						
192	Henne	Mis, Mis U	1940	900	1,274,590	70,951						
193	Hoffsomer	Mis Lime	1947	280	93,340	38,655						
194	Jenday	Mis, Mis U	1944	1,500	673,724	59,730						
195	Johnson	Mis, Mis U	1932	1,200	3,161,366	42,377						
196	Lindsborg	Vio, Simpson, Ord	1938	4,720	5,272,627	497,789						
197	Maxwell	Mis, Mis L	1948	80	5,952	4,585						
198	Mc Pherson	Mis, Mis U, Vio, Ord	1926	2,080	1,333,721	84,600						
199	Paden	Mis, Mis U	1943	2,000	1,652,594	347,042						
200	Reuben	Simpson, Ord	1949	40	2,094	2,094						
201	Ritz - Canton	Lan K C, Pen, Mis, Mis U, Vio, Ord, Simpson, Ord	1929	15,000	41,161,000	563,618						
202	Roxbury	Mis, Mis U	1938	1,500	2,722,038	123,345						
203	Roxbury, South	Mis, Mis U	1942	300	274,031	22,795						
204	Roxbury, S. E.	Mis, Mis U	1943	80	24,060	3,074						
205	Twin Mounds	Mis, Mis U	1948	200	87,151	48,410						
206	Voshell	Mis, Mis U, Vio, Ord, Simp, Ord, Arb, Ord	1929	3,580	27,586,023	297,702						
207	Doles Park	Mis Lime	1947				80	x	x			
208	Ritz - Canton	x	x				1,500	x	x			
	Meade											
209	Adams Ranch	Mis, Mis U	1945	160	812	x	x	162,343				

LINE NUMBER	NUMBER OF WELLS[c]			WELLS PRODUCING[f] DEC. 1949			RESERVOIR PRESSURE LB PER SQ INCH		SECONDARY RECOVERY[g]	CHARACTER OF OIL[h]		PRODUCING FORMATION					DEEPEST ZONE TESTED[n] TO END OF 1949	
	COMPLETED TO END 1949	1949		OIL		GAS	INITIAL	AVG./END 1949		GRAVITY A.P.I.	SULPHUR PER CENT	CHARACTER[i]	POROSITY PER CENT[j]	DEPTH TO TOP OF PRODUCING ZONE FT	PROD. THICKNESS AVG. FT / NET	STRUCTURE[m]	NAME	DEPTH OF HOLE, FT
		COMPLETED	ABANDONED	FLOWING	ARTIFICIAL LIFT													
147	3				3					40.0	x	D	x	3,212	2	x	x	x
148	43	7			37					45.0	x	L D	x	2,980-3,200	130-5	x	x	x
149		2			2					46.0	x	L D	x	3,148-3,378	8-8	x	x	x
150	338	5			343	x				42.0	x	D	x	3,333	14	x	x	x
151										42.0	x	D	x			x	x	x
152	4		1		2					44.0	x	D	x	3,316	4	x	x	x
153	6				6					42.0	x	D	x	3,220	9	x	x	x
154	17	8			25					31.0	x	L L	x	4,000-4,650	13-10	x	x	x
155	1				1					39.2	x	L	x	3,520	4	x	x	x
156	6				4					37.0	x	L	x	3,630	2	x	x	x
157	2				2					39.0	x	L	x	3,745	30	x	x	x
158										x	x	L	x	3,487	19	x	x	x
159										35.8	x	L	x	3,414	6	x	x	x
160	109	16			125					26.5	x	D	x	3,720	12	x	x	x
161		5			5					30.0	x	D	x	3,537	2	x	x	x
162		2			2					29.0	x	D	x	3,839	3	x	x	x
163	2	1			3					43.2	x	L	x	3,750	6	x	x	x
164		1			1					36.0	x	L	x	x	x	x	x	x
165		1			1					29.0	x	L	x	4,400	14	x	x	x
166	23				14					35.8	x	L	x	3,005	30	x	x	x
												L	x	3,195	13	x		
167	50	1			51					40.0	x	D	x	3,507	5	x	x	x
												S	x	3,500	14	x		
168		1				1				x	x	L	x	x	x	x	x	x
169		1				1				x	x	L	x	x	x	x	x	x
170	5				5					36.6	x	D	x	3,279	16	x	x	x
	x	x	x			x					x	L	x	2,955	50	x	x	x
171	1				1	x				28.0	x	L	x	3,224	14	x	x	x
172	3				3					x	x	S	x	x	x	x	x	x
173	124		3		120					41.0	x	L	x	3,890	74	x	x	x
											x	L	x	3,925	33	x	x	x
174	3		3		3					41.8	x	L	x	4,405	6	x	x	x
175	x	x	x			x					x	L D	x	3,925-4,093	24-77	x	x	x
176	x	x	x			x					x	L	x	5,035	18	x	x	x
177	x	x	x			x					x	L	x	4,841	x	x	x	x
178	1				1					33.0	x	x	x	x	x	x	x	x
179	1				1					x	x	L	x	2,816	10	x	x	x
180	2				2					36.0	x	L	x	2,811	17	x	x	x
181	5				1					31.0	x	L	x	2,889	x	x	x	x
182	40	1	1		5					29.0	x	L	x	2,885	24	x	x	x
183		2			2					29.6	x	S	x	3,540	30	x	x	x
184	146				136					37.0	x	L	x	3,292	43	x	x	x
185	4	1			5					x	x	L	x	2,781	3	x	x	x
186	14				14					34.0	x	L	x	2,800	29	x	x	x
187	27		1		18					37.0	x	L L	x	2,363-3,007	19-14	x	x	x
188	50				50					34.0	x	S	x	3,323	3	x	x	x
189	10	3			13					34.0	x	L	x	2,665	x	x	x	x
190	115	4			119				e	41.0	x	D	x	3,274	24	x	x	x
191	12				12					36.0	x	L	x	2,621	14	x	x	x
192	24				22					36.0	x	L	x	2,660	5	x	x	x
193	5	2			7					35.0	x	L	x	2,752	20	x	x	x
194	34		1		30					37.0	x	L	x	2,970	15	x	x	x
195	12	2			11					36.0	x	L	x	3,032	14	x	x	x
196	110				105					34.0	x	L D	x	3,352-3,360	21-10	x	x	x
197	1	1			2					36.0	x	L	x	2,860	11	x	x	x
198	27	7			31					38.0	x	L L	x	2,967-3,140	11-6	x	x	x
199	42				42					38.0	x	L	x	2,752	18	x	x	x
200		1			1					x	x	S	x	3,652	86	x	x	x
												L	x	2,360	39	x	x	x
201	206		1		195					41.0	x	L	x	2,935	31	x	x	x
												L	x	3,440	4	x	x	x
202	37		2		34					35.0	x	L	x	2,684	5	x	x	x
203	4				4					35.0	x	L	x	2,658	7	x	x	x
204	1	1			2					35.0	x	L	x	2,665	9	x	x	x
205	4				4					x	x	L	x	2,844	7	x	x	x
206	74	1			66					41.0	x	L L	x	3,301-3,095	3-15	x	x	x
207	x	x	x			x					x	L	x	2,828	x	x	x	x
208	x	x	x			x					x	L	x	x	x	x	x	x
209	x	x	x							x	x	L	x	5,861	40	x	x	x

TABLE 18 - Continued OIL AND GAS PRODUCTION STATISTICS FOR WESTERN KANSAS

LINE NUMBER	FIELD (County)[a]	PRODUCING FORMATION NAME AND AGE[b]	YEAR OF DISCOVERY	OIL PRODUCTION			GAS PRODUCTION			GAS/OIL RATIO[d] MCF/BBL	CONDENSATE PRODUCTION Thousands of Bbl	
				AREA PROVED ACRES	BARRELS TO END OF 1949	BARRELS DURING 1949	AREA PROVED ACRES	THOUSAND CU FT[c] TO END OF 1949	THOUSAND CU FT[c] DURING 1949		TO END OF 1949	DURING 1949
210	Adams Ranch, E.	Morrow, Pen, Miss Lime	1947				160	Shut-in				
	Morton											
211	Richfield		1948	40	581	581						
	Ness											
212	Aldrich	Miss, Miss U	1929	6,040	1,864,117	233,091						
213	Arnold	Miss, Miss U	1944	200	244,565	36,244						
214	Kanssala	Miss, Miss U	1944	Abd.								
215	Manteno	Miss, Miss U	1945	160	41,235	5,640						
	Morton											
216	Hay, W.	Arb, Ord	1945	80	63,616	11,997						
	Pawnee											
217	Ash Creek, S. W.	Arb, Ord	1947	80	63,242	20,008						
218	Benson	Lan K C, Pen	1945	200	124,888	26,086						
219	Larned	Arb, Ord	1949	40	565	565						
220	Pawnee Rock [j]	Arb, Ord	1936	2,840	2,243,174	335,780	x	22,283,134	10,732,777			
221	Pawnee Rock, W.	Arb, Ord	1949	160	15,121	15,121						
222	Rutherford	Arb, Ord	1946	320	179,792	40,294						
223	Ryan, S. E.	Arb, Ord	1945	360	207,676	40,283						
224	Shady [j]	Arb, Ord	1945	120	3,552	3,552						
225	Zook	Arb, Ord	1941	80			1,040	7,784,824	1,231,465			
226	Benson, S. E.	Arb, Ord	1947				160	2,751,988	694,105			
227	Torrance	Arb, Ord	1947				160	x	x			
	Phillips											
228	Bow Creek	Lan K C, Pen	1939	40	42,646	2,450						
229	Dayton	Lan K C, Pen	1941	1,200	862,684	54,361						
230	Dayton, N.	Lan K C, Pen	1943	1,200	575,318	101,512						
231	Hansen	Lan K C, Pen, Arb, Ord	1943	1,000	1,167,192	250,734						
232	Huffstutter	Lan K C, Pen, Arb, Ord	1949	360	22,624	22,624						
233	Logan	Lan, Pen Arb, Ord	1946	400	296,732	58,711						
234	Bay	Reagan, Can	1940	4,000	9,658,410	1,248,383						
	Pratt											
235	Carmi	Vio, Simp, Arb, Ord	1942	3,680	7,768,260	721,030	3,000	32,466				
236	Chance	Arb, Ord	1946	600	263,866	123,052						
237	Chitwood	Lan K C, Pen, Vio, Ord, Simp, Ord, Arb, Ord	1943	3,040	5,168,685	671,528	3,000	5,922,437	467,915			
238	Clara	Simp, Ord	1948	200	67,250	56,048						
239	Coats	Arb, Ord	1944	400	313,087	42,147						
240	Frisbie	Lan K C, Pen, Simp, Ord	1943	400	249,885	34,995						
241	Frisbie, N. E.	Lan K C, Pen	1948	240	67,954	47,188						
242	Iuka	Arb, Ord	1937	2,000	1,469,957	161,109						
243	Ludwick	Simp, Ord	1944	80	25,139	1,186						
244	Moore	Simp, Ord	1949	40	6,651	6,651						
245	Shriver	Simp, Ord	1944	400	390,900	75,878	x	93,073	93,073			
246	Stark	Vio, Ord	1941	800	784,669	34,868						
247	Stoops	Vio, Ord	1946	160	68,747	10,313						
248	Stoops, S. E.	Vio, Ord	1946	40	10,077	2,007						
249	Cairo	Vio, Ord	1935				x	681,628	110,259			
	Reno											
250	Abbeyville	Lan K C, Pen	1927	640	643,352	52,992						
251	Albion	Miss, Miss U	1948	120	15,282	9,128						
252	Buhler	Simp, Ord, Miss, Miss L	1938	500	642,276	44,554						
253	Burrton - Houry	Hunton, Dev	1931	12,425	44,323,051	1,217,007						
254	Bilger	Vio, Ord	1934	1,200	4,233,168	193,529						
255	Lerado, S. W.	Vio, Ord	1944	160	95,764	14,293						
256	Morton	Lan K C, Pen	1942	40	32,528	3,235						
257	Peace Creek	Vio, Ord	1941	6,400	12,007,321	686,306						
258	Yoder	Miss, Miss U	1935	500	92,348	2,637						
259	Burrton	Miss, Miss U	1930				5,000	33,059,819	2,890,307			
260	Yoder	Miss, Miss U	1936				800	5,427,289	660,179			
	Rice											
261	Bowman, N.	Lan K C, Pen, Arb, Ord	1948	80	8,351	4,102						
262	Bredfeldt	Arb, Ord	1937	80	45,915	19,655						
263	Bredfeldt, W.	Arb, Ord	1939	80	55,854	2,778						
264	Chase	Lan K C, Pen, Arb, Ord	1931	17,000	53,385,288	4,733,313						
265	Click, S. E.	Lan K C, Pen	1947	40	9,662	3,651						
266	Doran	Arb, Ord	1936	720	866,603	140,027						
267	Doran, W.	Arb, Ord	1944	800	507,981	111,400						
268	Edwards	Arb, Ord	1936	3,260	11,401,331	948,985						
269	Engelland	Sooy, Pen	1949	40	2,985	2,985						
270	Gemeinhardt	Sooy, Pen	1948	40	13,399	9,915						
271	Geneseo	Lan K C, Pen Simp, Ord Arb, Ord	1947 1935 1934	40 100 5,600	10,418 102,228 25,921,334	9,559 19,719 1,742,106						
272	Heinz	Arb, Ord	1938	80	89,020	3,742						
273	Keller	Sooy, Pen	1943	40	36,271	2,750						
274	Lyons	Miss, Ord	1949	80	16,611	16,611						
275	Odessa	Lan K C, Pen	1949	40	3,337	3,337						
276	Odessa, South	Lan K C, Pen	1949	40	3,389	3,389						
277	Orth	Shaw, Lan K C, Pen, Pre-Cam	1932	1,200	1,989,266	195,994						

LINE NUMBER	NUMBER OF WELLS[e]			WELLS PRODUCING[f] DEC. 1949			RESERVOIR PRESSURE LB PER SQ INCH		SECONDARY RECOVERY[g]	CHARACTER OF OIL[h]		PRODUCING FORMATION					DEEPEST ZONE TESTED[n] TO END OF 1949	
	COMPLETED TO END 1949	1949		OIL		GAS	INITIAL	AVG./END 1949		GRAVITY A.P.I.	SULPHUR PER CENT	CHARACTER[i]	POROSITY PER CENT[j]	DEPTH TO TOP OF PRODUCING ZONE FT[k]	PROD. THICKNESS AVG. FT / NET	STRUCTURE[m]	NAME	DEPTH OF HOLE, FT
		COMPLETED	ABANDONED	FLOWING	ARTIFICIAL LIFT													
210	x	x	x								x	S L	x	5,680-5,826	x	x	x	x
211		1			1					x	x		x	x	x	x	x	x
212	28	1			29					34.0	x	L	x	4,428	2	x	x	x
213	5				5					36.0	x	L	x	4,529	21	x	x	x
214										34.0	x		x			x	x	x
215	3				3					35.0	x	L	x	4,551	14	x	x	x
216	2				2					x	x	D	x	3,650	9	x	x	x
217	3		1		2					37.0	x	D	x	3,780	13	x	x	x
218	5				5					27.0	x	L	x	3,628	68	x	x	x
219		1			1					38.0	x	D	x	3,851	36	x	x	x
220	45	3			48	x				39.0	x	D	x	3,825	16	x	x	x
221		4			4					x	x	D	x	3,785	12	x	x	x
222	8				7					41.8	x	D	x	3,815	9	x	x	x
223	7	2			9					37.0	x	D	x	3,689	3	x	x	x
224		3			3					x	x	D	x	4,067	13	x	x	x
225										x	x	D	x	4,066	8	x	x	x
226	x	x	x			x					x	D	x	4,023	28	x	x	x
227	x	x	x			x					x	D	x	3,846	11	x	x	x
228	1				1					40.0	x	L	x	3,111	53	x	x	x
229	22				21					35.8	x	L	x	3,430	8	x	x	x
230	22	1			23					37.0	x	L	x	3,406	16	x	x	x
231	26	3			29					30.0	x	D	x	3,530	6	x	x	x
232		9			9					x	x	L D	x	3,444-3,509	36-16	x	x	x
233	10				10					37.4	x	L	x	3,149	x	x	x	x
											x	D	x	3,575	6	x	x	x
234	107	28			135					30.3	x	S	x	3,540	13	x	x	x
235	98	5			103					36.8	x	L	x	4,266	31	x	x	x
236	11	8			19					34.3	x	L	x	3,695	3	x	x	x
237	76				74					40.0	x	L		4,286	21	x	x	x
											x	S	x	4,383	3	x	x	x
238	3	2			5					40.0	x	S	x	4,494	4	x	x	x
239	8				8					37.5	x	D	x	4,378	12	x	x	x
240	4				4					32.7	x	L S	x	3,947-4,292	8-7	x	x	x
241	4	2			6					37.0	x	L	x	3,812	19	x	x	x
242	21		3		18					37.0	x	D	x	4,354	5	x	x	x
243	2		1		1					39.0	x	S	x	4,489	27	x	x	x
244		1			1					37.2	x	S	x	4,349	x	x	x	x
245	7				7	x				39.0	x	S	x	4,557	7	x	x	x
246	16				13					x	x	L	x	4,121	2	x	x	x
247	4				4					39.2	x	L	x	4,446	x	x	x	x
248	1				1					39.0	x	L	x	4,482	8	x	x	x
249	x	x	x			x					x	L	x	4,278	8	x	x	x
250	16	6			14					38.0	x	L	x	3,540	9	x	x	x
251	3				3					31.0	x	L	x	3,640	x	x	x	x
252	8	3			7					38.5	x	S L	x	3,897-3,266	5-42	x	x	x
253	350	22			355					39.0	x	D	x	3,583	6	x	x	x
254	29	2	1		27					40.0	x	L	x	4,062	5	x	x	x
255	4				4					39.7	x	L	x	4,177	11	x	x	x
256	1				1					38.0	x	L	x	3,180	12	x	x	x
257	128	1	2		120					x	x	L	x	3,773	3	x	x	x
258	5				5					35.0	x	L	x	3,450	51	x	x	x
259	x	x	x			x					x	L	x	3,298	70	x	x	x
260	x	x	x			x					x	L	x	3,402	50	x	x	x
261	2				2					x	x	L D	x	x-3,325	x-8	x	Arbuckle lime	x
262	2				2					x	x	D	x	3,228	8	x	x	x
263	2		1		1					43.0	x	D	x	3,260	8	x	x	x
264	460	45	1		535					40.0	x	L D	x	2,940-3,245	10-10	x	x	x
265	1				1					26.3	x	L	x	3,056	5	x	x	x
266	19	5			24					46.0	x	D	x	3,291	20	x	x	x
267	20				20					38.0	x	D	x	3,265	13	x	x	x
268	106	2			108		1,090	980		40.0	x	D	x	3,278	5	A	Hunsl sand	x
269		1			1					37.0	x	C g	x	3,335	6	x	x	x
270	1				1					41.0	x	C g	x	3,282	11	x	x	x
	1			1			890	698		37.3	x	L	x	2,792	6	A	x	x
271	2				2					37.0	x	S	x	3,191	14	x	x	x
	199	2	2		190		1,100	1,020		39.0	x	D	x	3,132	14	A	Hunsl sand	x
272	2				2					42.0	x	D	x	3,254	14	x	x	x
273	1				1					45.0	x	S	x	3,240	3	x	x	x
274		2			2					x	x	S	x	3,316	16	x	x	x
275		1			1					29.9	x	L	x	3,092	6	x	x	x
276		1			1					38.9	x	L	x	3,069	6	x	x	x
277	47	4			46					40.0	x	L L	x	2,510-2,915	10-21	x	x	x

TABLE 1B - Continued OIL AND GAS PRODUCTION STATISTICS FOR WESTERN KANSAS

LINE NUMBER	FIELD (County)[a]	PRODUCING FORMATION NAME AND AGE[b]	YEAR OF DISCOVERY	OIL PRODUCTION			GAS PRODUCTION			GAS/OIL RATIO[c] MCF/BBL	CONDENSATE PRODUCTION Thousands of Bbl	
				AREA PROVED ACRES	BARRELS TO END OF 1949	BARRELS DURING 1949	AREA PROVED ACRES	THOUSAND CU FT[c] TO END OF 1949	THOUSAND CU FT[c] DURING 1949		TO END OF 1949	DURING 1949
278	Orth, W.	Arb, Ord	1944	320	180,887	115,010						
279	Pioneer	Arb, Ord	1942	200	109,853	19,485						
280	Ploog	Arb, Ord	1930	500	1,514,723	25,789						
281	Ponce	Sooy, Pen	1936	40	52,722	2,469						
282	Proffitt "A"	Arb, Ord	1949	80	8,625	8,625						
283	Prosper	Arb, Ord	1948	80	6,892	3,078						
284	Raymund	Lan K C, Pen, Arb, Ord	1929	2,500	12,193,027	495,171						
285	Rick, S. E.	Arb, Ord	1947	120	40,646	14,455						
286	Rickard	Lan K C, Pen, Arb, Ord	1935	200	169,038	7,861						
287	Ringwald	Lan K C, Pen	1949	300	31,816	31,816						
288	Smyres	Miss, Miss U	1942	1,160	1,759,416	221,594						
289	Volkland	Arb, Ord	1943	300	477,256	55,489						
290	Welch	Miss, Miss U	1924	2,180	5,464,667	261,971						
291	Welch, E.	Miss, Miss U	1941	80	30,699	1,551						
292	Welch, N.	Miss, Miss U	1937	160	90,670	4,730						
293	Welch, W.	Miss, Miss U	1948	160	21,969	17,128						
294	Wherry	Sooy, Pen	1933	7,280	10,543,497	289,533						
295	Wherry, N.	Sooy, Pen	1947	220	195,357	69,260						
296	Alden	Missener, Simp, Ord	1937				400	11,330,689				
297	Lyons	Arb, Ord	1888				1,500	7,253,492	48,802			
298	Orth	Lan, Pen	1933				640	3,381,900	128,621			
299	Quivira	Tarkio, Pen	1947				640	211,244				
	Knox											
300	Barry	Lan K C, Pen	1941	300	338,045	57,947						
		Arb, Ord		1,030	3,486,187	486,858						
301	Barry, E.	Lan K C, Pen	1947	40								
		Arb, Ord		260	218,048	110,141						
302	Barry, S. E.	Arb, Ord	1946	720	777,205	219,934						
303	Baun	Lan K C, Pen	1941	40	13,993	1,721						
304	Belmont	Lan K C, Pen	1949	40	1,894	1,894						
305	Berland	Arb, Ord	1948	1,600	322,841	301,931						
306	Berland, N.	Arb, Ord	1949	120	15,065	15,065						
307	Berland, N. E.	Arb, Ord	1949	40	5,351	5,351						
308	Chandler "A"	Arb, Ord	1948	540	295,229	231,012						
309	Dipita	Lan K C, Pen, Arb, Ord	1934	680	614,598	79,070						
310	Durr	Lan K C, Pen	1941	640	433,350	119,808						
311	Eagle Creek	Arb, Ord	1949	40	5,286	5,286						
312	Erway	Lan K C, Pen	1941	40	63,078	6,765						
313	Finnesy	Lan K C, Pen	1947	40	8,968	3,806						
314	Gick	Arb, Ord	1947	80	49,067	21,653						
315	Gra - Book	Arb, Ord	1948	120	63,283	60,844						
316	Hayden	Arb, Ord	1949	200	32,460	32,460						
317	Jelinek	Arb, Ord	1947	500	206,308	133,020						
318	Krueger	Lan K C, Pen	1948	540	93,227	86,928						
319	Laton	Lan K C, Pen	1927	3,560	3,488,538	253,623						
320	Locust Grove	Arb, Ord	1949	40	4,589	4,589						
321	Lone Star	Arb, Ord	1948	80	8,993	4,855						
322	Marc	Lan K C, Pen	1948	80	8,605	5,738						
323	Marcotte	Arb, Ord	1943	600	757,354	123,455						
324	Mc Clellan	Lan K C, Pen	1945	80	40,479	5,110						
325	Mc Hale	Arb, Ord	1948	300	66,578	61,137						
326	Mc Hale, S.	Arb, Ord	1949	40	3,699	3,699						
327	Nettie	Arb, Ord	1948	40	11,435	11,215						
328	Northampton	Arb, Ord	1948	800	489,690	338,107						
329	Nyra	Lan, Pen	1946	330	69,047	34,244						
330	Palco	Arb, Ord	1943	750	555,566	250,875						
331	Palco, S. E.	Arb, Ord	1949	80	3,077	3,077						
332	Palco Townsite	Arb, Ord	1945	40	13,232	3,099						
333	Paradise Creek	Lan K C, Pen, Arb, Ord	1947	960	905,189	276,490						
334	Plainville	Arb, Ord	1948	40	4,923	3,389						
335	Ray, S. E.	Reagan, Cam	1941	40	64,404	5,220						
336	Sulvers	Arb, Ord	1947	240	61,423	24,108						
337	Stockton	Lan K C, Pen	1937	200	86,094	15,485						
338	Vohs	Arb, Ord	1945	800	905,043	202,402						
339	Vohs, N. W.	Lan K C, Pen	1947	80	53,111	20,064						
340	Vohs, S.	Lan K C, Pen	1947	40	9,138	3,069						
341	Webster	Arb, Ord	1946	1,320	1,031,482	453,607						
342	Westhusin	Lan K C, Pen	1936	1,140	1,390,888	192,172						
343	Yohe	Lan K C, Pen	1949	120	11,745	11,745						
344	Zurich	Lan K C, Pen	1934	600	240,026	13,438						
345	Zurich Townsite	Arb, Ord	1944	300	156,477	67,921						
	Rush											
346	Otis - Albert	Reagan, Cam	1934	1,400	7,426,303	3,944,328						
347	Rush Center	Arb, Ord	1947	40	8,716	1,715						
348	Ryan	Arb, Ord	1945	1,500	1,191,728	265,683						
349	Weitzel	Lan K C, Pen	1947	80	27,701	5,330						
350	Otis	Reagan, Cam	1930				11,000	78,395,706	2,830,201			
351	Otis (Neva)	Neva, Per	x				x	152,645				
	Russell											
352	Atherton	Lan,K C, Pen	1935	2,000	2,294,717	162,621						
353	Atherton, N.	Arb, Ord	1945	80	55,990	4,587						

LINE NUMBER	NUMBER OF WELLS[e]			WELLS PRODUCING[f] DEC. 1949			RESERVOIR PRESSURE LB PER SQ INCH		SECONDARY RECOVERY[g]	CHARACTER OF OIL[h]		PRODUCING FORMATION					DEEPEST ZONE TESTED[n] TO END OF 1949	
	COMPLETED TO END 1949	1949		OIL		GAS	INITIAL	AVG. /END 1949		GRAVITY A.P.I.	SULPHUR PER CENT	CHARACTER[i]	POROSITY PER CENT[j]	DEPTH TO TOP OF PRODUCING ZONE FT[k]	PROD. THICKNESS AVG. FT	NET	STRUCTURE[m]	NAME	DEPTH OF HOLE, FT
		COMPLETED	ABANDONED	FLOWING	ARTIFICIAL LIFT														
278	8	5			13					41.5	x	D x	x	3,233-3,240	37-3	x	x	x	x
279	4	1			5					40.2	x	D	x	3,281	5	x	x	x	x
280	9	1			5					47.0	x	D	x	3,252	19	x	x	x	x
281	1				1					34.0	x	S	x	3,388	40	x	x	x	x
282		2			2					50.0	x	D	x	3,344	7	x	x	x	x
283	1	1			2					46.0	x	D	x	3,231	13	x	x	x	x
284	72	10			82					42.0	x	L D	x	3,130-3,324	10-41	x	x	x	x
285	3				3					36.0	x	D	x	3,332	5	x	x	x	x
286	4				4					47.0	x	L D	x	2,995-3,330	7-21	x	x	x	x
287		7			7					37.7	x	L	x	2,947	5	x	x	x	x
288	32	1			33					37.0	x	L	x	3,339	25	x	x	x	x
289	7				7					34.0	x	D	x	3,221	30	x	x	x	x
290	61	7			68					35.0	x	L	x	3,370	44	x	x	x	x
291	2		1		1					34.0	x	L	x	3,341	5	x	x	x	x
292	3				3					34.0	x	L	x	3,334	32	x	x	x	x
293	1	2			3					55.0	x	L	x	3,486	18	x	x	x	x
294	91	4			67					x	x	S	x	3,358	22	x	x	x	x
295	7				7					x	x	S	x	3,423	10	x	x	x	x
296	x	x	x			x					x	S	x	x	x	x	x	x	x
297	x	x	x			x					x	L	x	x	x	x	x	x	x
298	x	x	x			x					x	L	x	x	x	x	x	x	x
299	x	x	x			x					x	L	x	x	x	x	x	x	x
300	7	1			8					32.6	x	L	x	3,370	35	A	x	x	x
	33	2			35					27.8	x	D	x	3,435	5	A	x	x	x
301	1				1					32.2	x	L	x	3,255	9	A	x	x	x
	7	1			8					28.2	x	D	x	3,487	6	A	x	x	x
302	21	3			24					23.0	x	D	x	3,479	7	A	x	x	x
303	1				1					30.0	x	L	x	3,057	15	x	x	x	x
304		1			1					x	x	L	x	3,353	8	x	x	x	x
305	9	41			50					29.2	x	D	x	3,802	5	x	x	x	x
306		3			3					29.0	x	D	x	3,776	2	x	x	x	x
307		1			1					29.0	x	D	x	3,766	6	x	x	x	x
308	12	5			17					25.0	x	D	x	3,457	2	x	x	x	x
309	10	10			20					33.0	x	L D	x	3,212-3,409	5-10	x	x	x	x
310	14	3			17					35.5	x	L	x	3,230	21	x	x	x	x
311		1			1					22.0	x	D	x	3,819	13	x	x	x	x
312	1				1					37.3	x	L	x	3,136	40	x	x	x	x
313	1				1					35.0	x	L	x	3,382	x	x	x	x	x
314	2				2					34.0	x	D	x	3,578	12	x	x	x	x
315	1	2			3					x	x	D	x	3,868	4	x	x	x	x
316		5			5					32.6	x	D	x	3,513	4	x	x	x	x
317	8	8			16					23.0	x	D	x	3,537	15	x	x	x	x
318	3	15			18					36.0	x	L	x	3,242	59	x	x	x	x
319	104	2			106					38.0	x	L	x	3,238	33	x	x	x	x
320		1			1					25.0	x	D		3,442	14	x	x	x	x
321	1	1			2					x	x	D		3,382	17	x	x	x	x
322	1	1			2					37.0	x	L		3,348	8	x	x	x	x
323	12	4			16					29.0	x	D		3,752	6	x	x	x	x
324	2				2					34.0	x	L		3,343	5	x	x	x	x
325	2	6			8					26.0	x	D		3,545	2	x	x	x	x
326		1			1					38.6	x	D		3,613	6	x	x	x	x
327	1				1					35.0	x	D		3,513	32	x	x	x	x
328	16	10			26					27.5	x	D		3,803	11	x	x	x	x
329	4	7			11					34.0	x	L		3,424	x	x	x	x	x
330	16	9			25					29.0	x	D		3,824	19	x	x	x	x
331		2			2					26.5	x	D		3,824	10	x	x	x	x
332	1				1					29.0	x	D		3,850	15	x	x	x	x
333	30	1			31					25.5	x	L D		3,400-3,576	5	x	x	x	x
334	1				1					38.0	x	D		3,613	2	x	x	x	x
335	1				1					38.0	x	S		3,600	6	x	x	x	x
336	6	1			7					x	x	D		3,466	x	x	x	x	x
337	4	2			6					38.5	x	L L		3,270-3,180	7-62	x	x	x	x
338	21				21					29.0	x	D		3,555	7	x	x	x	x
339	2				2					34.0	x	L		3,442	8	x	x	x	x
340	1				1					37.0	x	L		3,264	x	x	x	x	x
341	23	21			44					23.5	x	D		3,403	6	x	x	x	x
342	26	15			41					37.0	x	L		3,231	11	x	x	x	x
343		3			3					x	x	L		3,266	24	x	x	x	x
344	7	2			5					37.0	x	L		3,340	9	x	x	x	x
345	7				7					28.0	x	D		3,644	6	x	x	x	x
346	135	8			143					35.0	x	S		3,527	9	x	x	x	x
347	1				1					42.0	x	D		3,836	15	x	x	x	x
348	47	12			59					36.0	x	D		3,660	5	x	x	x	x
349	2				2					35.0	x	L		3,406	62	x	x	x	x
350	x	x	x			x					x	S		3,507	x	x	x	x	x
351	x	x	x			x					x	L		x	x	x	x	x	x
352	31	7			38					x	x	L		3,008	47	x	x	x	x
353	2				2					35.0	x	D		3,284	5	x	x	x	x

TABLE 1B - Continued OIL AND GAS PRODUCTION STATISTICS FOR WESTERN KANSAS

LINE NUMBER	FIELD (County)[a]	PRODUCING FORMATION NAME AND AGE[b]	YEAR OF DISCOVERY	OIL PRODUCTION			GAS PRODUCTION			GAS/OIL RATIO[c] MCF/BBL	CONDENSATE PRODUCTION Thousands of Bbl	
				AREA PROVED ACRES	BARRELS TO END OF 1949	BARRELS DURING 1949	AREA PROVED ACRES	THOUSAND CU FT[c] TO END OF 1949	THOUSAND CU FT[c] DURING 1949		TO END OF 1949	DURING 1949
354	Beisel	Arb, Ord	1944	40	16,978	2,533						
355	Big Creek	Lan K C, Pen Gorham, Pen, Arb, Ord	1935	6,800	11,156,240	759,081						
356	Boxberger	Lan K C, Pen	1935	160	213,498	6,435						
357	Claussen	Lan K C, Pen	1944	80	15,752	6,671						
358	Claussen, W.	Lan K C, Pen	1949	40	580	580						
359	Dillner, N. W.	Arb, Ord	1947	120	6,393	2,511						
360	Donovan	Lan K C, Pen	1935	220	191,871	11,056						
361	Dubuque	Lan K C, Pen, Arb, Ord	1935	640	578,232	57,256						
362	Ely	Shawnee, Pen	1949	40	2,180	2,180						
363	Eulert	Arb, Ord	1949	160	5,785	5,785						
364	Fairport	Lan K C, Stony, Pen, Reagan, Cam	1923	3,580	20,986,843	912,017						
365	Forest Hill	Arb, Ord	1941	1,020	2,114,545	373,036						
366	Forest Hill, N.	Arb, Ord	1947	120	23,551	14,684						
367	Gorham	Tarkio, Pen, Topeka, Pen, Lan K C, Pen, Arb Ord, Reagan, Cam	1926	8,780	35,934,899	1,453,135						
368	Gustason	Lan K C, Pen, Arb, Ord	1941	280	135,169	23,698						
369	Gustason, N. W.	Lan K C, Pen, Arb, Ord	1943	440	449,583	107,071						
370		Wabaunsee, Pen Topeka, Pen, Lan K C, Pen, Gorham Sd, Pen, Arb, Ord, Reagan, Cam, Pre-Cam, P C	1931	30,000	40,798,021	3,406,919						
371	Homer	Tarkio, Pen	1949	40	5,637	5,637						
372	Homer, S. E.	Shawnee, Pen	1949	40	115	115						
373	Jamie	Arb, Ord	1943	340	118,043	22,391						
374	Jerry	Lan K C, Pen	1942	320	49,598	3,243						
375	Meier	Arb, Ord	1948	120	33,769	29,197						
376	Ney	Arb, Ord	1948	200	71,140	41,482						
377	Parker	Lan K C, Pen	1948	120	10,767	10,767						
378	Parker, N. W.	Lan K C, Pen	1949	200	24,511	24,511						
379	Peister	Lan K C, Pen	1949	80	26,938	26,938						
380	Russell	Lan K C, Pen, Arb, Ord	1934	1,600	8,378,921	396,642						
381	Russell, E.	Arb, Ord	1949	120	7,628	7,628						
382	Strecker	Arb, Ord	1943	80	42,125	3,406						
383	Trapp	Shawnee, Lan K C, Pen	1929	38,500	114,560,513	8,935,073						
384	Trapp, E.	Lan K C, Pen	1949	40	1,621	1,621						
	Saline											
385	Hunter	Mis, Mis U	1943	700	867,382	86,565						
386	Hunter, N.	Mis, Mis U	1948	160	14,024	10,436						
387	Mentor	Maquoketa, Ord	1944	40	11,286	2,218						
388	Olsson	Maquoketa, Ord	1929	200	108,385	27,256						
389	Salina	Maquoketa, Ord	1943	700	604,093	93,129						
390	Salina, S.	Vio, Ord	1946	320	82,124	22,684						
	Scott											
391	Shallow Water	Mis, Mis U	1934	520	1,727,511	41,858						
	Sedgwick											
392	Bartholemew	Mis, Mis U	1948	200	37,831	25,758						
393	Bartholemew, N.	Mis, Mis U	1949	80	15,246	15,246						
394	Chambers	Mis, Mis U	1948	80	10,643	6,546						
395	Clearwater	Lan K C, Pen	1944	300	79,612	8,540						
396	Cross	Lan K C, Pen	1929	160	75,138	2,096						
397	Curry	K C, Pen	1947	280	66,471	38,471						
398	Eastborough	Mis, Mis U, Vio, Ord	1929	1,000	x	69,983						
399	Fairview	Mis, Mis U	1948	200	49,187	38,894						
400	Fairview, N.	Burgess Sd, Pen	1948	120	23,065	18,048						
401	Goodrich	Lan K C, Pen Mis, Mis U Maquoketa, Ord	1928	840	4,416,138	97,933						
402	Greenwich	Mis, Mis U Vio, Ord Simpson, Ord	1928	800	10,910,056	183,778						
403	Hinkle	Burgess Sd, Pen	1946	80	10,153	276						
404	Hohn	Lan K C, Pen	1945	120	44,233	29,290						
405	Petrie	Simpson, Ord	1945	40	50,239	9,452						
406	Robbins	Mis, Mis U	1929	700	2,530,138	80,271						
407	Schulte	Simpson, Ord	1947	240	134,663	29,100	x	166,952	166,952			
408	Valley Center	Maquoketa, Vio, Ord, Lan K C, Pen	1928	1,500	21,764,049	111,403						
409	White Cotton	Burgess Sd, Pen	1948	300	67,223	60,036						
	Smith											
410	Kismet	x	1948	40	12,680	5,369						
411	Liberal, S. E.	Pen Sd, Pen	1947	80	34,616	12,114	160	3,926,079	1,525,785			
412	Liberal	Chase, Per	1947				320	1,280,376	424,043			
	Sheridan											
413	Adell	Lan K C, Pen	1944	1,280	1,610,023	379,597						
414	Studley	Lan K C, Pen	1943	320	299,585	39,426						
415	Studley, S. W.	Lan K C, Pen	1945	40	31,512	5,551						

LINE NUMBER	NUMBER OF WELLS[E]			WELLS PRODUCING[F] DEC. 1949			RESERVOIR PRESSURE LB PER SQ INCH		SECONDARY RECOVERY[G]	CHARACTER OF OIL[A]		PRODUCING FORMATION					DEEPEST ZONE TESTED[H] TO END OF 1949	
	COMPLETED TO END 1949	1949		OIL		GAS	INITIAL	AVG./END 1949		GRAVITY A.P.I.	SULPHUR PER CENT	CHARACTER[I]	POROSITY PER CENT[J]	DEPTH TO TOP OF PRODUCING ZONE FT	PROD. THICKNESS AVG. FT / NET	STRUCTURE[B]	NAME	DEPTH OF HOLE, FT
		COMPLETED	ABANDONED	FLOWING	ARTIFICIAL LIFT													
354	1				1					28.6	x	D		3,266	18	x	x	x
355	174	15			166					29.5	x	L S D	x x x	2,908 3,152 3,171	48 5 5	x x x	x	x
356	4				4					41.0	x	L	x	3,147	4	x	x	x
357	1	1			2					39.0	x	L	x	2,854	7	x	x	x
358		1			1					39.0	x	L	x	2,841	13	x	x	x
359	3				3					32.0	x	D	x	3,328	9	x	x	x
360	5				3					38.5	x	L	x	3,193	7	x	x	x
361	7	4			11					41.0	x	L D	x	3,275-3,330	3-5	x	x	x
362		1			1					33.0	x	L	x	2,950	2	x	x	x
363		4			4					32.0	x	D	x	3,271	13	x	x	x
364	182	16			179					36.0	x	L S	x	2,950-3,211	12-5	x	x	x
365	42	4			46					39.0	x	D	x	3,320	3	x	x	x
366	3				3					39.0	x	D	x	3,270	13	x	x	x
367	283	1	10		250					36.0	x	x S L L D S	x x x	2,765 3,289 3,299	x x x	x x	x	x
368	3	4			7					38.0	x	L D L D	x x	3,050 3,021	x x	x x	x	x
369	12				12					37.5	x	L L S	x x x	3,322 2,400 2,675	x x x	x x	x	x
370	701	50			746					39.0	x	D S x	x x x	2,985 3,165 3,192	x x x	x x	x	x
371		1			1					x	x	L	x	x	x	x	x	x
372		1			1					33.0	x	L	x	2,608	18	x	x	x
373	6	2			8					38.0	x	D	x	3,319	x	x	x	x
374	3				2					38.0	x	L	x	2,985	x	x	x	x
375	2	1			3					37.0	x	D	x	3,325	6	x	x	x
376	5				5					x	x	D	x	3,356	6	x	x	x
377		3			3					x	x	L	x	3,018	14	x	x	x
378		5			5					36.0	x	L	x	3,042	7	x	x	x
379		2			2					39.0	x	L	x	3,092	8	x	x	x
380	65	8			70					33.0	x	L D	x	3,195-3,280	9-6	x	x	x
381		3			3					33.0	x	D	x	3,271	11	x	x	x
382	2				2					48.0	x	D L	x x	3,342 2,889	3 7	x x	x	x
383	1,302	25			1,303					39.0	x	L D	x x	3,062 3,252	2 3	x x	x	x
384		1			1					x	x	L	x	3,075	7	x	x	x
385	19				19					35.0	x	L	x	2,681	2	x	x	x
386	1	3			4					36.0	x	L	x	2,675	21	x	x	x
387	1				1					35.3	x	D	x	3,256	15	x	x	x
388	3	3			6					35.0	x	D	x	3,303	12	x	x	x
389	24				22					34.0	x	D	x	3,223	8	x	x	x
390	7				7					34.0	x	L	x	3,246	8	x	x	x
391	12				9					31.0	x	L	x	4,670	16	x	x	x
392	1	4			5					x	x	L	x	3,715	48	x	x	x
393		2			2					35.1	x	L	x	3,750	25	x	x	x
394	1	1			2					44.0	x	L	x	3,546	4	x	x	x
395	5		1		4					37.0	x	L	x	3,020	11	x	x	x
396	2				1					35.0	x	L	x	2,690	40	x	x	x
397	3	3			6					x	x	L	x	2,594	x	x	x	x
398	x				26					x	x	L L	x	2,956-3,238	x	x	x	x
399	1	5			6					44.0	x	L	x	2,960	2	x	x	x
400	1	2			3					40.0	x	S L	x x	2,973 2,614	4 2	x x	x	x
401	36		1		28					39.0	x	L S S	x x x	3,010 3,334 2,985	10 3 3	x x x	x	x
402	42	2	7		31					40.0	x	L S	x x	3,321 3,350	5 4	x x	x	x
403	2				2					40.0	x	S	x	2,992	x	x	x	x
404	3				3					34.0	x	L	x	2,680	5	x	x	x
405	1				1					39.9	x	S	x	3,387	3	x	x	x
406	50	4			52					43.0	x	L	x	3,090	12	x	x	x
407	7				7	x				44.6	x	S	x	3,658	x	x	x	x
408	57				51					43.0	x	S L	x	3,368-3,366	x-2	x	x	x
409	3	9			12					48.0	x	S	x	2,937	2	x	x	x
410	1				1					38.0	x	x	x	x	x	x	x	x
411	2				2	x				x	x	S	x	6,206	x	x	x	x
412	x	x	x			x				x	x	D	x	x	x	x	x	x
413	38				38					41.5	x	L	x	3,758	4	x	Granite wash	x
414	6				6					47.0	x	L	x	3,808	9	x	x	x
415	1				1					37.0	x	L	x	3,610	26	x	x	x

TABLE 1B - Continued OIL AND GAS PRODUCTION STATISTICS FOR WESTERN KANSAS

LINE NUMBER	FIELD (County)[a]	PRODUCING FORMATION NAME AND AGE[b]	YEAR OF DISCOVERY	OIL PRODUCTION			GAS PRODUCTION			GAS/OIL RATIO[d] MCF/BBL	CONDENSATE PRODUCTION Thousands of Bbl	
				AREA PROVED ACRES	BARRELS TO END OF 1949	BARRELS DURING 1949	AREA PROVED ACRES	THOUSAND CU FT[c] TO END OF 1949	THOUSAND CU FT[c] DURING 1949		TO END OF 1949	DURING 1949
	Stafford											
416	Ahnert	Arb, Ord	1941	40	38,799	2,277						
417	Bedford	Lan K C, Pen, Arb, Ord	1940	870	1,304,561	68,916						
418	Black Cloud	Arb, Ord	1949	40	3,885	3,885						
419	Brock	Arb, Ord	1944	640	277,454	38,446						
420	Curtis	Arb, Ord	1942	400	443,615	72,328						
421	Drach	Arb, Ord	1937	2,280	3,822,279	481,876						
422	Drach, N. W.	Arb, Ord	1947	200	65,131	21,041						
423	Farmington	Kinderhook Sd, Mis, Arb, Ord	1943	640	834,621	89,694						
424	Fischer	Arb, Ord	1938	120	318,586	12,562						
425	Fischer, N. W.	Arb, Ord	1948	440	261,943	242,174						
426	Gates	Arb, Ord	1948	930	1,858,097	295,504						
427	Gates, South	Arb, Ord	1949	40	5,206	5,206						
428	Gray	Lan, Pen	1946	120	31,595	4,831						
429	Gross	Arb, Ord	1949	160	13,051	13,051						
430	Grunder	Lan K C, Pen	1943	40	17,878	1,788						
431	Hart	Arb, Ord	1949	80	5,064	5,064						
432	Hazel	Arb, Ord	1942	240	228,841	13,192						
433	Heyen	Arb, Ord	1943	500	344,317	117,925						
434	Hildebrand	Vio, Ord	1949	80	1,865	1,865						
435	Hildebrand, S.	Vio, Ord	1949	160	18,965	18,965						
436	Hufford	Arb, Ord	1948	330	113,408	72,374						
437	James	Arb, Ord	1948	200	153,405	26,367						
438	Jordan	Lan K C, Pen	1936	280	666,699	25,160						
439	Kelly	Vio, Ord	1948	40	4,204	1,883						
440	Kemlesorth	Lan K C, Pen	1947	270	137,377	78,757						
441	Kipp	Lan K C, Pen	1937	500	567,955	23,089						
442	Kipp, N. E.	Lan K C, Pen	1946	120	123,708	23,011						
443	Leesburg	Arb, Ord	1938	640	2,238,145	113,980						
444	Max	Lan K C, Pen, Arb, Ord	1938	960	1,377,444	220,389						
445	Mc Candless	Simpson, Ord	1944	200	261,148	52,666						
446	Merle	Lan K C, Pen	1949	320	48,861	48,861						
447	Mueller, W.	Arb, Ord	1949	40	930	930						
448	Moon	Lan K C, Pen	1948	40	4,066	3,696						
449	Nellie	Lan K C, Pen	1948	40	15,831	8,131						
450	Neola	Vio, Ord	1948	40	10,850	6,463						
451	O'Connor	Lan K C, Pen	1948	40	3,527	2,057						
452	Oscar	Arb, Ord	1949	40	2,913	2,913						
453	Prairie Home	Arb, Ord	1949	80	5,516	5,516						
454	Pundsack	Arb, Ord	1947	160	58,070	32,704						
455	Rattlesnake	Lan K C, Pen	1938	80	102,655	13,620						
456	Rattlesnake, W.	Lan K C, Pen	1944	40	21,934	3,994						
457	Richardson	Arb, Ord	1930	1,200	9,936,819	596,684						
458	Richland	Arb, Ord	1944	200	171,203	12,206						
459	Riley	Lan K C, Pen	1940	120	119,216	6,695						
460	Rothgarn	Arb, Ord	1943	200	98,997	26,476						
461	Rothgarn, E.	Arb, Ord	1948	120	26,294	21,262						
462	Sandago	Arb, Ord	1947	240	86,585	22,961						
463	Sand Hill	Arb, Ord	1944	80	40,941	5,697						
464	Saundra	Arb, Ord	1946	260	99,497	24,053						
465	Shaeffer	Lan K C, Pen, Arb, Ord	1941	300	296,171	15,174						
466	Silver Bell	Arb, Ord	1949	80	5,427	5,427						
467	Sittner	Lan K C, Pen, Arb, Ord	1937	1,600	2,770,476	432,910						
468	Sittner, S.	Arb, Ord	1936	750	1,683,936	129,022						
469	Snider	Simpson, Arb, Ord	1936	320	380,303	21,404						
470	Snider, S.	Simpson, Ord	1938	420	910,879	97,418						
471	Spangenburg	Arb, Ord	1943	40	68,700	6,099						
472	St. John	Lan K C, Pen, Arb, Ord	1935	1,200	2,392,981	86,321						
473	St. John Tomsite	Arb, Ord	1944	280	250,788	29,633						
474	Stafford	Viola, Arb, Ord	1940	800	2,646,703	161,507						
475	Syms	Arb, Ord	1943	160	127,555	27,625						
476	Syms, E.	Arb, Ord	1948	40	4,378	1,960						
477	Van Lieu	Arb, Ord	1943	120	185,530	11,289						
478	Zenith	Misener, Vio, Ord	1937	11,140	24,137,877	428,814						
479	O'Connor	Arb, Ord	1947				160	x	x			
480	Zenith - Peace Creek	Vio, Ord	1937				2,000	6,373,015	500,677			
	Sumner											
481	Alton	Simpson, Ord	1949	40	1,669	1,669						
482	Amess	Simpson, Ord	1937	40	138,893	13,253						
483	Anson	Mis, Mis L	1948	120	25,922	16,423						
484	Bellman	Simpson, Ord	1945	320	186,332	27,464						
485	Caldwell	Simpson, Ord	1929	200	1,352,065	35,247						
486	Chandler	Mis, Mis L	1942	40	9,451	150						
487	Churchill	Stalnaker, Pen, Arb, Ord	1927	1,000	1,321,337	13,523						
488	Corbin	x	1948	40	32,514	32,024						
489	Latta	Lan K C, Pen	1927	400	1,104,504	32,310						
490	Margaret	Arb, Ord	1946	320	81,926	12,550						

LINE NUMBER	NUMBER OF WELLS[6]			WELLS PRODUCING[7] DEC. 1949			RESERVOIR PRESSURE LB. PER SQ. INCH		SECONDARY RECOVERY[8]	CHARACTER OF OIL[9]		PRODUCING FORMATION					DEEPEST ZONE TESTED[10] TO END OF 1949	
	COMPLETED TO END 1949	1949		OIL		GAS	INITIAL	AVG./END 1949		GRAVITY A.P.I.	SULPHUR PER CENT	CHARACTER[1]	POROSITY PER CENT[1]	DEPTH TO TOP OF PRODUCING ZONE FT.[8]	PROD. THICKNESS AVG. FT. / NET	STRUCTURE[8]	NAME	DEPTH OF HOLE, FT.
		COMPLETED	ABANDONED	FLOWING	ARTIFICIAL LIFT													
416	1				1					28.0	x	D	x	3,784	4	x	x	x
417	16				14					35.0	x	L D	x	3,400-3,859	19-9	x	x	x
418		1			1					41.0	x	D	x	3,427	15	x	x	x
419	10				10					30.6	x	D	x	3,680	4	x	x	x
420	10				9					29.0	x	D	x	3,693	7	x	x	x
421	49	4			52					35.0	x	D	x	3,710	12	x	x	x
422	5	1			6					38.7	x	D	x	4,261	15	x	x	x
423	17				17					39.0	x	S D	x	4,417	16	x	x	x
424	3				3					36.0	x	D	x	3,641	7	x	x	x
425	6	8			14					37.0	x	D	x	3,635	7	x	x	x
426	28	3			31					38.7	x	D	x	3,679	39	x	x	x
427		1			1					x	x	D	x	3,748	4	x	x	x
428	3				3					30.0	x	L	x	3,743	x	x	x	x
429		4			4					35.0	x	D	x	3,705	7	x	x	x
430	1				1					40.0	x	L	x	3,945	15	x	x	x
431		2			2					35.0	x	D	x	3,826	6	x	x	x
432	6				6					38.0	x	D	x	3,692	9	x	x	x
433	17	2			17					39.0	x	D	x	3,652	2	x	x	x
434		2			2					40.0	x	L	x	3,797	7	x	x	x
435		4			4					x	x	L	x	3,809	21	x	x	x
436	6	3			9					x	x	D	x	3,754	7	x	x	x
437	5				5					x	x	D	x	3,554	9	x	x	x
438	7				7					33.5	x	L	x	3,722	5	x	x	x
439	1				1					37.0	x	L	x	3,718	27	x	x	x
440	6	3			9					34.0	x	L	x	3,505	x	x	x	x
441	11				11					34.1	x	L	x	3,827	79	x	x	x
442	3				3					32.2	x	L	x	3,844	x	x	x	x
443	16				16					37.5	x	D	x	4,153	10	x	x	x
444	16	16			32					35.4	x	L D	x	3,356-3,570	16-5	x	x	x
445	4	2			6					37.0	x	S	x	4,251	16	x	x	x
446		8			8					34.0	x	L	x	3,669	10	x	x	x
447		1			1					36.0	x	D	x	3,658	11	x	x	x
448	1				1					30.0	x	L	x	x	x	x	x	x
449	1				1					35.0	x	L	x	x	x	x	x	x
450	1				1					40.0	x	L	x	3,920	4	x	x	x
451	1				1					29.0	x	L	x	3,768	11	x	x	x
452		1			1					35.0	x	D	x	3,797	9	x	x	x
453		2			2					40.0	x	D	x	3,512	3	x	x	x
454	3	1			4					27.0	x	D	x	3,735	8	x	x	x
455	1	1			2					32.0	x	L	x	3,698	48	x	x	x
456	1				1					37.0	x	L	x	3,759	7	x	x	x
457	60	2			62					41.0	x	D	x	3,537	62	x	x	x
458	5				5					37.0	x	D	x	4,225	15	x	x	x
459	2				2					30.0	x	L	x	3,323	5	x	x	x
460	3	3			5					35.6	x	D	x	3,569	19	x	x	x
461	1	2			3					35.6	x	D	x	3,513	5	x	x	x
462	7		1		6					32.4	x	D	x	3,480	9	x	x	x
463	2				2					36.4	x	D	x	3,540	10	x	x	x
464	8		1		7					37.0	x	D	x	3,586	18	x	x	x
465	5				4					39.5	x	L D	x	3,546	4	x	x	x
466		1			1					30.0	x	D	x	3,779	11	x	x	x
467	56	1			57					38.0	x	L D	x	3,278-3,600	36-6	x	x	x
468	22	3			25					34.0	x	D	x	3,501	6	x	x	x
469	3				3					43.0	x	S D	x	3,365-3,324	6-20	x	x	x
470	12		1		11					34.0	x	S	x	3,402	6	x	x	x
471	1				1					37.0	x	D	x	3,691	6	x	x	x
472	26		4		20					37.5	x	L D	x	3,588-4,075	32-12	x	x	x
473	7	3			9					35.0	x	D	x	3,919	5	x	x	x
474	22				21					40.5	x	L D	x	3,836-3,945	14-10	x	x	x
475	3	2			4					37.0	x	D	x	3,580	14	x	x	x
476	1				1					37.0	x	D	x	3,565	10	x	x	x
477	3				3					36.0	x	D	x	4,069	11	x	x	x
478	372		52		231					41.3	x	S L	x	3,804-3,860	20-5	x	x	x
479	x	x	x			x					x	D	x	4,061	3	x	x	x
480	x	x	x			x					x	L	x	x	x	x	x	x
481		1			1					47.5	x	S	x	4,709	10	x	x	x
482	1				1					42.0	x	S	x	4,394	7	x	x	x
483	3				3					x	x	L	x	3,755	13	x	x	x
484	7		1		6					51.0	x	S	x	3,797	5	x	x	x
485	4				3					47.0	x	S	x	4,765	19	x	x	x
486	1				1					x	x	L	x	3,413	26	x	x	x
487	62		7		34					36.0	x	S D	x	1,820-2,632	25-24	x	x	x
488	1				1					47.0	x	x	x	x	x	x	x	x
489	12		2		10					38.0	x	L	x	3,042	14	x	x	x
490	6				6					59.0	x	D	x	3,470	x	x	x	x

TABLE 1B - Continued OIL AND GAS PRODUCTION STATISTICS FOR WESTERN KANSAS

LINE NUMBER	FIELD (County)[2]	PRODUCING FORMATION NAME AND AGE[b]	YEAR OF DISCOVERY	OIL PRODUCTION AREA PROVED ACRES	OIL PRODUCTION BARRELS TO END OF 1949	OIL PRODUCTION BARRELS DURING 1949	GAS PRODUCTION AREA PROVED ACRES	GAS PRODUCTION THOUSAND CU FT[c] TO END OF 1949	GAS PRODUCTION THOUSAND CU FT[c] DURING 1949	GAS/OIL RATIO[d] MCF/BBL	CONDENSATE PRODUCTION Thousands of Bbl TO END OF 1949	CONDENSATE PRODUCTION Thousands of Bbl DURING 1949
491	Oxford	Stalnaker, Layton, Pen / Arb, Ord	1927	800	15,786,670	134,113						
492	Oxford, W.	Arb, Ord	1926	240	612,042	35,658						
493	Padgett	Mis, Mis U	1924	1,040	x	x						
494	Padgett, N. E.	Mis, Mis U	1949	160	10,400	10,400						
495	Perth	Simpson, Ord	1945	400	377,017	116,250						
496	Platter (Abd.)	Mis, Mis U	1926	80	96,734							
497	Val Verde	Bartlesville, Pen	1945	40	3,913	642						
498	Vernon, N.	Mis, Mis U	1915	740	x	x						
499	Wellington	Mis, Mis U	1929	2,160	7,133,412	308,586						
500	Zyba	Simpson, Ord	1937	320	251,370	33,557						
501	Zyba, S. W.	Simpson, Ord	1944	400	145,470	100,939						
	Trego											
502	Cotton	Arb, Ord	1945	40	21,633	3,468						
503	Cotton, E.	Arb, Ord	1947	80	23,270	9,220						
504	Ellis, N. W.	Arb, Ord	1944	200	144,977	16,561						
505	Wakeeney	Lan K C, Pen	1934	640	741,696	37,852						
506	Wakeeney, E.	Lan K C, Pen	1949	40	3,764	3,764						

[1] Abandoned.
[2] Production includes Shady, Zook, and Benson, S. E.
[3] Gas includes Pawnee Rock, Ryan, Ash Creek, and Behrgns.

TABLE 2 - SUMMARY OF DRILLING OPERATIONS IN WESTERN KANSAS

IMPORTANT WILDCATS DRILLED IN 1949

LINE NUMBER	COUNTY	LOCATION SEC	LOCATION TWP	LOCATION RGE	TOTAL DEPTH, FT	SURFACE FORMATION	DEEPEST HORIZON TESTED	DRILLED BY	INITIAL PRODUCTION PER DAY OIL, U.S. BBL	INITIAL PRODUCTION PER DAY GAS, MILLIONS CU FT	REMARKS
1	Phillips	6	2	18 W	3,480	Ogallala, Ter	Lan K C, Pen	B & R Drlg. Inc.	58		Huffstutter
2	Rooks	8	7	19 W	3,456	Ogallala, Ter	Arb, Ord	Pack & Braden	25		Locust Grove
3	Rooks	28	7	19 W	3,472	Ogallala, Ter	Lan K C, Pen	Harry Gore	66		Belmont
4	Rooks	31	8	19 W	3,517	Niobrara, Cre	Arb, Ord	Heathman-Honaker	122		Hayden
5	Rooks	4	9	18 W	3,511	Niobrara, Cre	Arb, Ord	Continental	892		Yobe
6	Rooks	17	9	18 W	3,619	Niobrara, Cre	Arb, Ord	Petroleum, Inc.	50		Mc Hale, S.
7	Rooks	17	10	19 W	3,772	Ogallala, Ter	Arb, Ord	Heathman-Honaker	267		Berland, N. E.
8	Rooks	18	10	19 W	3,771	Ogallala, Ter	Arb, Ord	Birmingham-Bartlett	3,000		Berland, N.
9	Rooks	2	10	20 W	3,831	Ogallala, Ter	Arb, Ord	Francis Oil & Gas	167		Eagle Creek
10	Rooks	3	10	20 W	3,834	Ogallala, Ter	Arb, Ord	Heathman Drlg. Co.	463		Palco, S. E.
11	Graham	1	10	21 W	3,841	Niobrara, Cre	Arb, Ord	D. G. Hansen	155		Muilenberg
12	Graham	9	10	21 W	3,822	Niobrara, Cre	Lan K C, Pen	M. B. Armer	32		Teal
13	Graham	23	10	21 W	3,784	Niobrara, Cre	Arb, Ord	Derby & Peel	159		Morlan
14	Russell	33	11	15 W	3,322	Graneros, Cre	Arb, Ord	Anschutz Drlg.	3,000		Eulert
15	Ellis	22	11	16 W	3,460	Carlile, Cre	Lan K C, Pen	Huber & Crowe	54		Chrisler
16	Ellis	3	11	18 W	3,536	Carlile, Cre	Arb, Ord	Eldorado Ref.	190		Meistrell
17	Ellis	12	11	20 W	3,800	Carlile, Cre	Lan K C, Pen	Appleman & Derby	390		Warren
18	Trego	13	11	23 W	4,050	Ogallala, Ter	Lan K C, Pen	B & R & Heller Co.	51		Wakeeney, E.
19	Russell	29	12	14 W	2,854	Carlile, Cre	Lan K C, Pen	Crown Oil	12		Claussen, W.
20	Ellis	27	12	16 W	3,443	Carlile, Cre	Arb, Ord	E. H. Adair	203		Emmeram, N. E.
21	Russell	25	13	14 W	3,288	Carlile, Cre	Arb, Ord	Shields	107		Russell, E.
22	Ellis	5	13	17 W	3,631	Carlile, Cre	Lan K C, Pen	W. L. Hartman	47		Reed
23	Ellis	9	13	17 W	3,803	Carlile, Cre	Arb, Ord	Texas Co.	144		Catherine Townsite
24	Russell	16	14	13 W	2,434	Graneros, Cre	Tarkio, Pen	John Lindas	40		Homer, S. E.
25	Russell	17	14	13 W	2,435	Carlile, Cre	Tarkio, Pen	Lindas & Murfin	90		Homer
26	Ellis	21	14	16 W	3,383	Carlile, Cre	Arb, Ord	M. B. Armer	173		Dreiling
27	Russell	7	15	12 W	3,310	Carlile, Cre	Lan K C, Pen	J & L Drlg. Co.	833		Parker, N. W.
28	Russell	14	15	13 W	3,283	Carlile, Cre	Arb, Ord	E. H. Adair	143		Trapp, E.
29	Russell	15	15	13 W	3,318	Carlile, Cre	Shawnee, Pen	Eldorado Ref.	80		Ely
30	Russell	24	15	13 W	3,320	Carlile, Cre	Lan K C, Pen	E. H. Adair	810		Piester
31	Ellis	2	15	19 W	3,703	Carlile, Cre	Arb, Ord	Peel-Hardman	182		Antonio Townsite
32	Ellsworth	31	16	10 W	3,394	Carlile, Cre	Arb, Ord	Ferrell Drlg.	48		Palacky
33	Mc Pherson	33	17	2 W	3,570	Sumner, Per	Simpson, Ord	Texas Pacific	108		Bonaville
34	Barton	32	17	13 W	3,347	Graneros, Cre	Arb, Ord	Harwood & Stickle	50		Rowland
35	Barton	34	17	13 W	3,408	Graneros, Cre	Lan K C, Pen	Hay & Ash	121		Mc Cauley
36	Barton	19	17	14 W	3,411	Graneros, Cre	Arb, Ord	Ben Brack	36		Axmen
37	Mc Pherson	17	18	2 W	3,732	Sumner, Per	Simpson, Ord	Texas Pacific	25		Reuben
38	Rice	32	18	6 W	3,600	Dakota, Cre	Lan K C, Pen	Atlantic Ref.	330		Odessa
39	Rice	32	18	10 W	3,090	Dakota, Cre	Lan K C, Pen	Anderson-Prichard	375		Ringwald
40	Barton	24	18	11 W	3,299	Quat	Arb, Ord	Eldorado Ref.	3,000		Meadowside
41	Rice	9	19	6 W	3,585	Quat	Lan K C, Pen	J. M. Huber	40		Odessa, S.

LINE NUMBER	NUMBER OF WELLS[e]			WELLS PRODUCING[f] DEC. 1949			RESERVOIR PRESSURE LB PER SQ INCH		SECONDARY RECOVERY[g]	CHARACTER OF OIL[h]		PRODUCING FORMATION					DEEPEST ZONE TESTED[n] TO END OF 1949	
	COMPLETED TO END 1949	1949		OIL		GAS	INITIAL	AVG./END 1949		GRAVITY A.P.I.	SULPHUR PER CENT	CHARACTER[i]	POROSITY PER CENT[j]	DEPTH TO TOP OF PRODUCING ZONE FT[k]	PROD. THICKNESS AVG. FT.[l] NET	STRUCTURE[m]	NAME	DEPTH OF HOLE, FT
		COMPLETED	ABANDONED	FLOWING	ARTIFICIAL LIFT													
491	43		4		35					37.0	x	S	x	2,020	16	x		x
											x	S	x	2,510	20	x	x	
492	3	3			6					37.0	x	D	x	2,890	5	x		x
493	23				23					38.0	x	D	x	3,674	31	x	x	x
494		4			4					38.0	x	L	x	3,474	28	x	x	x
495	12				12					41.0	x	L	x	3,396	16	x	x	x
496			1							37.9	x	S	x	4,264	14	x	x	x
497	1				1					40.0	x	L	x	3,315	27	x	x	x
498	26				23					39.0	x	S	x	3,263	15	x	x	x
499	136	4			133					40.0	x	L	x	3,443	22	x	x	x
500	8				8					50.0	x	L	x	3,655	11	x	x	x
501	2	8			10					42.5	x	S	x	3,866	3	x	x	x
												S	x	3,917	12	x	x	x
502	1				1					38.0	x	D	x	3,980	34	x	x	x
503	2				2					40.0	x	D	x	3,942	6	x	x	x
504	5				5					35.0	x	D	x	3,925	2	x	x	x
505	6		1		5					38.0	x	L	x	3,619	8	x	x	x
506		1			1					38.0	x	L	x	3,524	x	x	x	x

TABLE 2 - Continued SUMMARY OF DRILLING OPERATIONS IN WESTERN KANSAS

IMPORTANT WILDCATS DRILLED IN 1949											
LINE NUMBER	COUNTY	LOCATION SEC	LOCATION TWP	LOCATION RGE	TOTAL DEPTH, FT	SURFACE FORMATION	DEEPEST HORIZON TESTED	DRILLED BY	INITIAL PRODUCTION PER DAY OIL, U.S. BBL	INITIAL PRODUCTION PER DAY GAS, MILLIONS CU FT	REMARKS
42	Barton	12	19	12 W	3,407	Quat	Arb, Ord	Aladdin & Crowe	120		Cheyenne View
43	Barton	14	19	12 W	3,455	Quat	Arb, Ord	Aladdin & Crowe	98		Cheyenne View, S. W.
44	Barton	23	19	12 W	3,362	Quat	Arb, Ord	Aladdin & Hannum	511		Hammer, N.
45	Barton	12	19	15 W	3,568	Quat	Cam Sd, Cam	B & R Drlg, Inc.	121		Merten, S. E.
46	Rice	34	20	7 W	3,362	Cong, Pen	Arb, Ord	Skelly Oil	50		Engelland
47	Rice	13	20	10 W	3,345	Quat	Arb, Ord	Henderson	62		Proffitt
48	Barton	7	20	12 W	3,433	Quat	Lan K C, Pen	C. U. Bay	302		Sunny Valley
49	Barton	14	20	12 W	3,380	Quat	Arb, Ord	Williams Oil Co.	50		Buckbee
50	Barton	26	20	12 W	3,376	Quat	Arb, Ord	Black & Davis	510		Bryant, S. E.
51	Barton	30	20	12 W	3,531	Quat	Arb, Ord	Bay Pet. Co.	30		Rolling Green, E.
52	Barton	34	20	12 W	3,415	Quat	Arb, Ord	E. H. Adair	189		Workman, S. E.
53	Pawnee	23	20	16 W	3,775	Quat	Arb, Ord	Vickers Pet.	203		Pawnee Rock, W.
54	Stafford	3	21	12 W	3,435	Quat	Arb, Ord	E. H. Adair	169		Black Cloud
55	Stafford	2	21	13 W	3,528	Quat	Arb, Ord	M. B. Armer	242		Prairie Home
56	Stafford	16	21	13 W	3,712	Quat	Arb, Ord	Westgate-Greenland	132		Grow
57	Stafford	24	21	13 W	3,669	Quat	Arb, Ord	Mid-States	26		Mueller, W.
58	Pawnee	28	21	16 W	3,881	Quat	Arb, Ord	Sunray Oil	25		Larned
59	Stafford	3	22	13 W	3,736	Quat	Arb, Ord	Faulkner	125		Gates, S.
60	Stafford	4	22	13 W	3,802	Quat	Arb, Ord	E. H. Adair	33		Moon
61	Stafford	10	22	13 W	3,786	Quat	Arb, Ord	Ferrell Drlg.	408		Silverbell
62	Stafford	24	22	14 W	3,805	Quat	Arb, Ord	Anschutz Drlg.	240		Oscar
63	Stafford	36	22	14 W	3,832	Quat	Arb, Ord	Musgrove Pet.	472		Hart
64	Harvey	15	23	3 W	3,355	Quat	Mis, Mis U	Westgate-Greenland		29.9	Jones, N. E.
65	Harvey	21	23	3 W	3,363	Quat	Mis, Mis U	B & R Drlg. Co.		2.8	Jones
66	Stafford	32	23	13 W	3,679	Quat	Lan K C, Pen	Crown Oil	779		Merle
67	Stafford	11	24	12 W	3,830	Quat	Viola, Ord	Delta & B & R Drlg.	96	2.0	Hildebrand, S.
68	Pratt	1	26	14 W	4,445	Quat	Simpson, Ord	Deep Rock & Kine	40		Moore
69	Sedgwick	30	27	4 W	3,750	Quat	Mis, Mis U	Huber & Pabco	677		Bartholomew, N.
70	Harper	13	31	9 W	4,449	Quat	Mis, Mis U	Drillers Gas Co.	32		Grabs
71	Barber	15	33	11 W	4,610	Quat	Mis, Mis U	Barbara Oil Co.	146		Rhodes
72	Sumner	10	35	2 W	4,719	Quat	Simpson, Ord	Champlin Ref.	1,298		Alton
73	Decatur	32	4	29 W	4,114	Niobrara, Cre	Arb, Ord	Glenn Nye			Dry & Abd
74	Rooks	1	6	20 W	3,574	Cgallala, Ter	Granite	Veeder Supply			Dry & Abd
75	Rooks	1	6	18 W	3,450	Cgallala, Ter	Arb, Ord	G. L. Reasor			Dry & Abd
76	Rooks	20	6	17 W	3,515	Cgallala, Ter	Arb, Ord	Westgate-Greenland			Dry & Abd
77	Rooks	5	6	20 W	3,646	Cgallala, Ter	Granite Wash	Harry Gore			Dry & Abd
78	Sheridan	1	6	27 W	4,140	Niobrara, Cre	Lan K C, Pen	Peel-Hardman			Dry & Abd
79	Rooks	25	7	19 W	3,350	Niobrara, Cre	Arb, Ord	Derby Oil			Dry & Abd
80	Rooks	14	7	20 W	3,570	Niobrara, Cre	Arb, Ord	W. L. Hartman			Dry & Abd
81	Rooks	13	7	20 W	3,544	Niobrara, Cre	Arb, Ord	Aladdin			Dry & Abd
82	Graham	27	7	22 W	3,766	Niobrara, Cre	Arb, Ord	D. G. Hansen			Dry & Abd

TABLE 2 - Continued SUMMARY OF DRILLING OPERATIONS IN WESTERN KANSAS

IMPORTANT WILDCATS DRILLED IN 1949

LINE NUMBER	COUNTY	LOCATION SEC	LOCATION TWP	LOCATION RGE	TOTAL DEPTH, FT	SURFACE FORMATION	DEEPEST HORIZON TESTED	DRILLED BY	INITIAL PRODUCTION PER DAY OIL, U.S. BBL	INITIAL PRODUCTION PER DAY GAS, MILLIONS CU FT	REMARKS
83	Rooks	34	7	16 W	3,515	Niobrara, Cre	Arb, Ord	Fink-Peterson			Dry & Abd
84	Rooks	28	7	16 W	3,315	Niobrara, Cre	Arb, Ord	Pickerell Drlg.			Dry & Abd
85	Rooks	16	7	19 W	3,471	Niobrara, Cre	Arb, Ord	Sam K. Pack			Dry & Abd
86	Graham	20	7	22 W	3,973	Niobrara, Cre	Arb, Ord	Pack-Braden-Green			Dry & Abd
87	Rooks	12	7	20 W	3,569	Niobrara, Cre	Arb, Ord	W. L. Hartman			Dry & Abd
88	Rooks	16	8	18 W	3,494	Niobrara, Cre	Arb, Ord	S. A. Murphy			Dry & Abd
89	Rooks	19	8	19 W	3,537	Niobrara, Cre	Arb, Ord	Pack-Braden-Green			Dry & Abd
90	Rooks	30	8	19 W	3,494	Niobrara, Cre	Cong	Sam K. Pack			Dry & Abd
91	Rooks	35	8	18 W	3,527	Niobrara, Cre	Arb, Ord	Westgate-Greenland			Dry & Abd
92	Rooks	35	8	19 W	3,526	Niobrara, Cre	Arb, Ord	Harry Gore			Dry & Abd
93	Graham	28	9	21 W	4,002	Ogallala, Ter	Arb, Ord	Arner			Dry & Abd
94	Graham	12	9	21 W	3,773	Ogallala, Ter	Arb, Ord	D. G. Hansen			Dry & Abd
95	Rooks	17	9	19 W	3,625	Ogallala, Ter	Arb, Ord	Petroleum Inc.			Dry & Abd
96	Graham	36	9	22 W	4,035	Ogallala, Ter	Arb, Ord	Cities Service			Dry & Abd
97	Rooks	10	9	18 W	3,660	Niobrara, Cre	Arb, Ord	Anschutz Drlg.			Dry & Abd
98	Rooks	30	9	18 W	3,652	Niobrara, Cre	Arb, Ord	N. C. R. A.			Dry & Abd
99	Rooks	21	9	20 W	3,867	Ogallala, Ter	Cong	Heathman Drlg.			Dry & Abd
100	Rooks	20	9	20 W	3,980	Ogallala, Ter	Arb, Ord	Virginia Drlg.			Dry & Abd
101	Rooks	23	9	20 W	3,810	Niobrara, Cre	Arb, Ord	Virginia Drlg.			Dry & Abd
102	Rooks	16	9	20 W	3,850	Ogallala, Ter	Arb, Ord	Birmingham-Bartlett			Dry & Abd
103	Rooks	15	10	18 W	3,847	Ogallala, Ter	Arb, Ord	Hinkle Oil Co.			Dry & Abd
104	Graham	12	10	21 W	3,889	Ogallala, Ter	Arb, Ord	C & G Drlg. Co.			Dry & Abd
105	Graham	7	10	21 W	3,950	Ogallala, Ter	Arb, Ord	Hine Drlg. Co.			Dry & Abd
106	Graham	21	10	21 W	3,842	Niobrara, Cre	Arb, Ord	Arner & Atlantic			Dry & Abd
107	Ottawa	22	10	2 W	3,504	Quat	Vio, Ord	Westgate-Greenland			Dry & Abd
108	Osborne	32	10	15 W	3,950	Ogallala, Ter	Arb, Ord	B & H & Wilcox			Dry & Abd
109	Rooks	29	10	20 W	3,834	Niobrara, Cre	Arb, Ord	Daley Oil			Dry & Abd
110	Osborne	34	10	15 W	3,418	Ogallala, Ter	Simpson, Ord	Sohio			Dry & Abd
111	Russell	3	11	15 W	3,484	Graneros, Cre	Arb, Ord	Westgate-Greenland			Dry & Abd
112	Ellis	13	11	20 W	3,710	Niobrara, Cre	Arb, Ord	Appleman-Peel			Dry & Abd
113	Ellis	18	11	18 W	3,553	Niobrara, Cre	Arb, Ord	Harbar			Dry & Abd
114	Ellis	32	11	20 W	3,900	Niobrara, Cre	Arb, Ord	Sohio & Veeder			Dry & Abd
115	Russell	26	12	15 W	3,308	Carlile, Cre	Arb, Ord	Nadel & Gussman			Dry & Abd
116	Ellis	29	12	20 W	3,506	Niobrara, Cre	Arb, Ord	Texas Co.			Dry & Abd
117	Russell	11	12	15 W	3,229	Dakota, Cre	Arb, Ord	Nadel & Gussman			Dry & Abd
118	Ellis	19	12	18 W	3,924	Ogallala, Ter	Cong	Anschutz Drlg.			Dry & Abd
119	Ellis	26	12	20 W	3,925	Ogallala, Ter	Arb, Ord	W. L. Hartman			Dry & Abd
120	Ellis	35	12	18 W	3,718	Niobrara, Cre	Arb, Ord	Darby-Bothwell			Dry & Abd
121	Russell	12	13	13 W	3,275	Dakota, Cre	Arb, Ord	B & H Drlg. Co.			Dry & Abd
122	Russell	5	13	14 W	3,159	Dakota, Cre	Arb, Ord	Peel & Hardman			Dry & Abd
123	Russell	18	13	15 W	3,400	Dakota, Cre	Arb, Ord	B & H & Wilcox			Dry & Abd
124	Russell	13	13	15 W	3,280	Dakota, Cre	Arb, Ord	Derby			Dry & Abd
125	Ellis	23	13	19 W	3,750	Carlile, Cre	Arb, Ord	Virginia Drlg. Co.			Dry & Abd
126	Saline	17	13	1 W	3,223	Quat	Arb, Ord	Bay Pet. Co.			Dry & Abd
127	Ellis	15	14	18 W	3,670	Carlile, Cre	Arb, Ord	Deep Rock & Hine			Dry & Abd
128	Russell	6	14	15 W	3,283	Carlile, Cre	Granite	Phil-Han			Dry & Abd
129	Trego	32	14	24 W	4,515	Ogallala, Ter	Arb, Ord	Stanolind			Dry & Abd
130	Ellsworth	35	14	10 W	3,155	Carlile, Cre	Arb, Ord	Cities Service			Dry & Abd
131	Russell	17	15	14 W	3,342	Graneros, Cre	Arb, Ord	N. C. R. A.			Dry & Abd
132	Ellis	5	15	19 W	3,741	Carlile, Cre	Arb, Ord	Alyward Drlg.			Dry & Abd
133	Ellis	4	15	17 W	3,510	Carlile, Cre	Arb, Ord	Lindas Oil Co.			Dry & Abd
134	Barton	19	16	14 W	3,452	Carlile, Cre	Arb, Ord	Anschutz Drlg.			Dry & Abd
135	Barton	23	16	11 W	3,440	Carlile, Cre	Arb, Ord	Derby Drlg. Co.			Dry & Abd
136	Saline	27	16	1 W	2,732	Quat	Mis, Chat	L. B. Jackson			Dry & Abd
137	Barton	32	17	14 W	3,462	Graneros, Cre	Arb, Ord	Hinkle Oil Co.			Dry & Abd

IMPORTANT WILDCATS DRILLED IN 1949

LINE NUMBER	COUNTY	LOCATION SEC	LOCATION TWP	LOCATION RGE	TOTAL DEPTH, FT	SURFACE FORMATION	DEEPEST HORIZON TESTED	DRILLED BY	INITIAL PRODUCTION PER DAY OIL, U.S. BBL	INITIAL PRODUCTION PER DAY GAS, MILLIONS CU FT	REMARKS
138	Mc Pherson	28	17	1 W	3,291	Dakota, Cre	Arb, Ord	Anderson-Prichard			Dry & Abd
139	Barton	7	17	11 W	3,367	Graneros, Cre	Arb, Ord	Aledo Oil Co.			Dry & Abd
140	Rush	14	17	20 W	4,115	Carlile, Cre	Arb, Ord	Huber			Dry & Abd
141	Barton	34	17	14 W	3,439	Graneros, Cre	Arb, Ord	Amerada			Dry & Abd
142	Barton	3	17	14 W	3,555	Graneros, Cre	Arb, Ord	A. B. W. Drlg. Co.			Dry & Abd
143	Rice	19	18	9 W	3,313	Dakota, Cre	Arb, Ord	Derby Drlg. Co.			Dry & Abd
144	Rice	21	18	7 W	3,418	Dakota, Cre	Arb, Ord	Heathman-Mallard			Dry & Abd
145	Mc Pherson	3	18	3 W	3,694	Dakota, Cre	Arb, Ord	Texas Pacific			Dry & Abd
146	Rice	21	18	8 W	3,473	Dakota, Cre	Arb, Ord	Continental			Dry & Abd
147	Barton	4	19	14 W	3,580	Qua t	Arb, Ord	Finston Bros.			Dry & Abd
148	Barton	25	19	12 W	3,380	Qua t	Arb, Ord	Hartman			Dry & Abd
149	Rush	30	19	19 W	3,741	Carlile, Cre	Arb, Ord	John Lindas			Dry & Abd
150	Barton	33	19	15 W	3,705	Qua t	Arb, Ord	Musgrove Pet. Co.			Dry & Abd
151	Mc Pherson	24	20	1 W	3,468	Qua t	Arb, Ord	Bay Pet. Co.			Dry & Abd
152	Barton	6	20	12 W	3,461	Qua t	Arb, Ord	Mouser Drlg. Co			Dry & Abd
153	Barton	34	20	11 W	3,322	Qua t	Arb, Ord	Hinkle Oil Co.			Dry & Abd
154	Scott	1	20	34 W	5,105	Qua t	Mis Lime	Texas Co.			Dry & Abd
155	Rice	31	20	6 W	3,450	Qua t	Mis Lime	Apex & Hinkle			Dry & Abd
156	Pawnee	11	20	17 W	3,966	Qua t	Arb, Ord	Vickers Pet. Co.			Dry & Abd
157	Marion	27	20	2 E	3,115	Sumner, Per	Arb, Ord	Deiter, et al			Dry & Abd
158	Stafford	12	21	13 W	3,594	Qua t	Arb, Ord	Westgate-Greenland			Dry & Abd
159	Stafford	17	21	14 W	3,775	Qua t	Arb, Ord	M. B. Arner			Dry & Abd
160	Pawnee	10	21	16 W	3,874	Qua t	Arb, Ord	Magnolia Pet.			Dry & Abd
161	Rice	30	21	9 W	3,500	Qua t	Arb, Ord	Nat'l. Assoc. Pet. Co.			Dry & Abd
162	Pawnee	25	21	15 W	3,886	Qua t	Arb, Ord	Continental			Dry & Abd
163	Pawnee	4	22	17 W	4,040	Qua t	Arb, Ord	Vickers & Gulf			Dry & Abd
164	Harvey	17	22	2 E	3,545	Qua t	Arb, Ord	Meyer Trustee			Dry & Abd
165	Rice	4	22	8 W	3,792	Qua t	Arb, Ord	Wm. Graham			Dry & Abd
166	Hodgeman	24	22	25 W	5,214	Qua t	Arb, Ord	Texas Co.			Dry & Abd
167	Harvey	14	23	1 W	3,591	Qua t	Arb, Ord	Hager			Dry & Abd
168	Harvey	9	23	3 W	3,390	Qua t	Mis Lime	Lebo, et al			Dry & Abd
169	Reno	26	23	5 W	4,000	Qua t	Arb, Ord	Homer-Snowden			Dry & Abd
170	Stafford	32	24	12 W	4,240	Qua t	Arb, Ord	Lion Oil Co.			Dry & Abd
171	Reno	29	24	9 W	4,316	Qua t	Arb, Ord	Ausherman, et al			Dry & Abd
172	Stafford	7	24	15 W	4,236	Qua t	Arb, Ord	Continental			Dry & Abd
173	Sedgwick	25	25	2 W	4,090	Qua t	Arb, Ord	C. L. Carlock			Dry & Abd
174	Sedgwick	30	25	1 W	3,000	Qua t	Lan K C, Pen	C. L. Carlock			Dry & Abd
175	Pratt	34	26	13 W	4,451	Qua t	Arb, Ord	Olsen Drlg. Co.			Dry & Abd
176	Hamilton	4	26	41 W	6,422	Qua t	Arb, Ord	Bay Pet. Co.			Dry & Abd
177	Pratt	20	27	11 W	4,589	Qua t	Arb, Ord	Skelly Oil Co.			Dry & Abd
178	Kingman	12	27	5 W	4,086	Qua t	Arb, Ord	H. C. Patton			Dry & Abd
179	Ford	29	27	22 W	5,250	Qua t	Mis Lime	Continental			Dry & Abd
180	Kiowa	19	28	17 W	4,940	Qua t	Vio, Ord	Huber			Dry & Abd
181	Sedgwick	31	28	2 E	3,150	Qua t	Mis Lime	J. W. Wiley			Dry & Abd
182	Kingman	25	29	10 W	4,736	Qua t	Arb, Ord	Herndon Drlg. Co.			Dry & Abd
183	Sedgwick	29	29	3 W	3,325	Qua t	Lan K C, Pen	Carlock, et al			Dry & Abd
184	Sumner	11	30	2 E	2,602	Sumner, Per	Lan K C, Pen	Carlock, et al			Dry & Abd
185	Meade	4	30	30 W	5,893	Qua t	Mis Lime	Northern Nat. Gas			Dry & Abd
186	Harper	33	31	9 W	4,767	Qua t	Arb, Ord	Wakefield, et al			Dry & Abd
187	Harper	21	32	7 W	5,050	Qua t	Arb, Ord	Gulf Oil Co.			Dry & Abd
188	Harber	21	32	13 W	5,075	Qua t	Arb, Ord	White Eagle			Dry & Abd
189	Barber	4	33	15 W	5,300	Enid, Per	Arb, Ord	Russell Maguire			Dry & Abd
190	Sumner	25	34	1 E	3,865	Sumner, Per	Simpson, Ord	Aladdin Pet. Corp.			Dry & Abd
191	Sumner	11	35	1 E	3,876	Sumner, Per	Arb, Ord	Gralapp & Mc Neish			Dry & Abd

Oil And Gas Developments In East And East Central Texas During 1949

By JOHN S. BELL,* Member AIME,
and BILLY W. EVANS,** Junior Member AIME

The year 1949 for the petroleum industry of East and East Central Texas was, as in the remainder of the country, a period of transition in which the industry endeavored to adjust operations to meet the lessening demands for petroleum products. The adjustment involved production curtailments to prevent waste and more careful handling of budgets to allow all operations to continue despite the reduced incomes caused by the diminished production. Along with the reduced production rates, refinery operations and geophysical work were also curtailed. However, leasing and wildcatting indicated increases in 1949 over 1948.

During the year, 139.7 million bbl of oil were produced in East and East Central Texas, which is comprised of Railroad Commission Districts 5 and 6, as shown on the map. This production represents 18.7 per cent of the 746.2 million bbl of crude produced in Texas and 7.6 per cent of the total United States production. The 1949 production is a decrease of 20 per cent, or 34.4 million bbl, from that of 1948.

Wildcat drilling increased considerably during the year, 186 wells having been drilled by December 31 as compared with 122 for 1948. This exploratory work resulted in new production from 17 zones in 15 new fields and from one additional zone in each of eight fields discovered prior to 1949.

As listed in Table 2, the 15 new fields include 11 new oil and six new gas reservoirs. The Sub-Clarksville and Paluxy formations each contributed four new oil pools, the Rodessa two and the Strawn one. Of the six new gas reservoirs, three are Rodessa, two are Pettit and one is Woodbine. In the old fields, new pay discoveries were as follows: Woodbine, one oil; Rodessa, two oil and two gas; James, one gas; and Pettit, one oil and one gas. The new fields considered most important at present and their producing formation are East Sherman, Strawn; Tennessee Colony, Rodessa; North Lansing, Rodessa; Trawick, Pettit; Red Springs, Rodessa; Pewitt Ranch, Paluxy; and Pine Mills, Sub-Clarksville. Other new discoveries were Bud Lee, Walter Fair and Lakeview in the Paluxy; Mineola, Coats and Nolan Edwards in the Sub-Clarksville; and Freestone in the Rodessa. None of these new fields have been developed sufficiently to permit accurate estimates of the ultimate productive acreage to be made. However, conservative estimates of their reserves are 4.1 million bbl.

The new pay zones in old fields include oil accumulations in the Woodbine at Buffalo; Rodessa at South Tyler, Huxley and Coke; and Pettit at South Henderson. Gas reserves were discovered in the Rodessa at Long Lake, James at Opelika, and Pettit at Steward's Mill.

The one important extension during the year was in Alba Field, Wood County, where Shell Oil Co.'s Consumers Lignite Co. 1 extended field limits one and one-half miles south, increasing the field oil acreage to approximately 1,500 acres. At present there are 22 producing wells in the field, an increase of 18 since 1948.

One of the most interesting wildcats completed in the district during the year was Humble's R. P. Mc Watters 1, discovery well of the Freestone Field and the deepest well drilled in East and East Central Texas. Although having reached its 16,347 ft total depth in the Buckner formation prior to the end of 1948, the well was completed as a gas-condensate producer in the Pettit at 8,315 ft on Jan. 29, 1949.

Geophysical work generally decreased during the year, approximately 1,000 crew weeks being spent in the district. Leasing activity increased slightly during the year. Approximately 500,000 acres of new leases were acquired.

At present there are 30 natural gasoline plants operating in the district with a total production of 3,384,000 gal liquid products per day. There are nine cycling plants in operation with a daily output of 535,000 gal.

Reduced allowables during 1949 resulted in a 34.4 million bbl decrease in production for the district from that of 1948. The brunt of the allowable cut was borne by the large fields in the district with but two of the major fields, New Hope and Sherman Area, indicating increased production for the year. The increased production in the New Hope Field resulted largely from the water injection program which was initiated in 1945. The Sherman Area Field experienced very rapid development during the year. It is interesting to note that the decrease in production in one field alone, the East Texas Field, was nearly as much as the total yearly production from the Van and Hawkins Fields, the next two largest producing areas in the district.

The Van Field, one of the first unit-operated fields in the country, completed its twentieth producing year in 1949. This field has produced over 200 million bbl of oil with only a 418 lb drop from the estimated original

* *Division Petroleum Engineer, Humble Oil and Refining Co., Tyler, Texas.
**Junior Petroleum Engineer, Humble Oil and Refining Co., Tyler, Texas.

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bottom hole pressure of 1,230 lb, decreasing approximately two lb for each million bbl of oil produced.

Woodbine reservoirs accounted for 84.4 per cent of the total 1949 production from the district. Twenty-six active Woodbine fields produced 117.9 million bbl during the year. The Paluxy formation in 16 fields produced 10.7 million bbl in 1949, representing 7.7 per cent of the district's annual total. Both percentages indicate decreases from last year.

Condensate production during the year was 6.8 million bbl, an increase of 0.2 million over 1948. The major condensate fields in the district are Carthage, which produced 3.1 million bbl; Chapel Hill, which produced 1.1 million bbl; and Opelika, which produced 0.8 million bbl.

There were 928 wells drilled in proven fields during the year; 775 were completed as oil wells, 46 as gas wells, and 107 abandoned dry. A total of 4,073,700 ft of hole was drilled, giving an average per well depth of 4,390 ft for the field wells, compared with 4,936 ft for wildcat wells. The East Texas Field led in proven field development with the completion of 469 oil wells and 21 dry holes. Grayson and Wood Counties experienced increased drilling activity. In Grayson County approximately 37 wells were added to the Sherman Area Field, which was discovered in 1947, increasing the production from that field sufficiently to place it in the top ten producing fields in the district. Wood County saw 125 oil wells, four gas wells and 16 dry holes drilled this year in its 12 proven fields. Other counties with ten or more producing wells drilled in proven fields were Anderson with 14 oil and eight gas; Harrison, 12 oil and 15 gas; Henderson, 16 oil and two gas; Hopkins, 31 oil and no gas; Marion, six oil and five gas; Panola, three oil and 21 gas; and Van Zandt, 11 oil and no gas. Bolivar Field, Denton County, showed renewed activity during the latter part of the year. At tne close of the year there were 63 rigs running in East and East Central Texas.

In summarizing, 1,114 wells were drilled in East and East Central Texas during 1949. Of this number 791 were completed as oil wells, 55 as gas wells and 268 were abandoned as dry holes.

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Humble Oil and Refining Co. employees contributing to the report are Mrs. J. E. Dorris and Mrs. R. G. Skidmore, both members of the Petroleum Engineering Section in the East Texas Division office at Tyler, Texas.

TABLE 3 - PRODUCTION STATISTICS
EAST TEXAS FIELD*

DATE YEAR 1949	AVERAGE RESERVOIR PRESSURE AT -3,300 FT LB. PER SQ. IN.	PRODUCTION BBL	NUMBER OF PRODUCING DAYS
January	1,008.39	8,979,894	20
February	1,008.20	8,907,398	20
March	1,005.73	8,557,661	19
April	1,009.45	7,705,799	17
May	1,013.27	7,735,864	17
June	1,018.87	7,306,861	16
July	1,024.37	6,915,974	15
August	1,025.16	6,912,594	15
September	1,034.40	7,307,440	16
October	1,028.88	7,738,070	17
November	1,030.03	8,125,020	18
December	1,027.66	7,334,718	16
January 1, 1950	1,029.65		
		93,527,293	206
	1948 Cumulative	2,575,702,934	
		93,527,293	
	1949 Cumulative	2,669,230,327	

*Data from Texas Railroad Commission.

TABLE I - OIL AND GAS PRODUCTION STATISTICS FOR EAST AND EAST CENTRAL TEXAS IN 1949

LINE NUMBER	FIELD (County)[a]	PRODUCING FORMATION NAME AND AGE[b]	YEAR OF DISCOVERY	OIL PRODUCTION			GAS PRODUCTION			GAS/OIL RATIO[c] MCF/BBL	CONDENSATE PRODUCTION (Thousands of Bbl)	
				AREA PROVED ACRES	BARRELS TO END OF 1949	BARRELS DURING 1949	AREA PROVED ACRES	MILLION CU FT TO END OF 1949	MILLION CU FT DURING 1949		TO END OF 1949	DURING 1949
1	Alba, *Wood*	Sub-Clarksville, Cre U	1948	1,500	92,600	58,600		x	x			
2	Angus, *Navarro*	Wolfe City, Cre U	1946	20	10,300	2,400	x	x	x			
3	Appleby, *Nacogdoches*	Travis Peak, Cre L	1943	x	x		20	x			x	
4	Barrette, *Navarro*	Woodbine, Cre U	1939	100	337,500	16,200	20	x	x		x	
5	Bethany, *Panola*	Total		20	100,000		46,305	235,062	22,315		598,000	166,000
		Cre U	1921	20	100,000		17,300	x	x		x	x
		Cre L	x				29,005	x	x		598,000	166,000
6	Beulah, *Angelina*	Queen City, Eoc	1935	10	x	x		x	x			
7	Blackfoot, *Anderson*	Total, Cre L	1944	1,159	401,800	214,700						
8	Boggy Creek, *Anderson, Cherokee*	Woodbine, Cre U	1925	960	4,426,900	43,800		x	x			
9	Bolivar, *Denton*	Strawn, Pen	1937	2,000	191,000	122,000	200	x	x			
10	Bonnie, South, & Lennan	Basal Walnut, Cre L	1902	2,500	130,800	2,300	x	x	x			
11	Boynton, *Smith*	Paluxy, Cre L	1946	80	216,200	40,200		x	x			
12	Bud Lee, *Smith*	Paluxy, Cre L	1949	80	9,400	9,400		2	2			
13	Buffalo, *Leon*	Woodbine, Cre U	1934	200	37,400	20,000	7,500	27,508	1,877		52,800	3,500
14	Calvert, *Robertson*	Nacatoch, Cre U	1944	850	556,100	80,500	100	x	x			
15	Camp Hill, *Anderson*	Sub-Clarksville, Cre U, Woodbine	1935	200	289,000			x				
16	Campbell, *Hunt*	Paluxy, Cre U	1943	80	249,100	30,200	80	12	1			
		Total		840	773,300	251,500	353,619	735,642	497,627		10,259,200	3,135,800
		L.Gl.Rose(Hill), Cre L	1939	40	14,500	2,600	24,931	81,534	13,431		1,049,100	137,800
		L.Gl.Rose(Glovd), Cre L	1947				640	2			2	
		L.Gl.Rose(L.Pettit), Cre L	1936				133,959	313,920	97,651		4,244,000	1,236,400
17	Carthage, *Panola*	L.Gl.Rose(L.Pettit), Cre L	1936	520	455,500	193,300	177,056	328,947	121,074		4,810,900	1,687,000
		Travis Peak, Cre L	1942	280	303,300	55,500	17,032	14,472	7,154		155,300	74,700
		Total		26,898	43,206,000	1,909,800	26,898	284,234	18,599		1,136,000	111,500
18	Cayuga, *Anderson, Freestone, & Henderson*	Woodbine, Cre U	1934	13,449	43,154,400	1,908,400	13,449	237,816	14,650		470,700	36,100
		L.Gl.Rose(Bodessa), Cre L		13,449	51,600	1,400	13,449	46,418	3,949		665,300	75,400
19	Cayuga Trinity, *Anderson*	L.Gl.Rose, Cre L	1939	20	41,700	1,400	x	x	x			
20	Cedar Creek, *Limestone*	Woodbine, Cre U	1927	30	336,000	3,000	x	x	x		x	
		Total		10,580	3,900,000	198,800	28,577	79,242	10,556		5,962,000	1,087,000
		Paluxy, Cre L	1940	40	50,000	21,000	3,562	24,296	1,285		3,443,000	874,000
21	Chapel Hill, *Smith*	L.Gl.Rose(Bodessa), Cre L	1938	40	74,000	5,000	7,000	38,205	4,710		1,957,000	175,000
		L.Gl.Rose(Pettit), Cre L	1940	10,000	3,374,000	173,000	18,015	16,739	4,561		562,000	38,000
		Travis Peak, Cre L	1947	500	42,000	12,000		x	x			
		Total		3,175	5,532,700	740,700	3,175	1,134	279		74,100	33,900
		Sub-Clarksville, Cre U	1948	1,335	414,700	264,300	1,335	8	5			
22	Cole, *Wood*	Paluxy, Cre L	1942	1,200	5,048,500	396,900	1,200	353	28			
		L.Gl.Rose(Young), Cre L	1945	640	79,500	79,500	640	773	246		74,100	33,900
23	Collinsville, *Grayson*	Strawn, Pen	1938	100	44,600	5,600	x	x	x			
24	Como, *Hopkins*	Loker, Cre U	1947	630	502,500	291,400	x	x	x			
25	Corsicana, *Navarro*	Nacatoch (Wolfe City), Cre U	1895	x	15,454,900	122,900	x	x	x			
26	Currie, *Navarro*	Woodbine, Cre U	1921	475	7,120,900	18,400	x	x	x			
27	De Berry, *Panola*	Blossom, Cre U	1926	100	29,000		50	x				
28	East Texas, *Cherokee, Gregg, Rusk, Smith, & Upshur*	Woodbine, Cre U	1930	102,547	2,669,230,300	93,527,300		869,954	30,583			
29	Elkhart, *Anderson*	Woodbine, Cre U	1938				1,600	8,897	6,513		34,800	24,900
30	Elysian, *Harrison*	Travis Peak, Cre L	1946				600	474	295		6,800	4,000
31	Eylau, *Bowie*	Smackover, Jur	1944	40	174,300	46,200	x	x	30			
32	Fair, *Smith*	L.Gl.Rose(Bodessa), Cre L	1948				x	x	x		x	x
33	Fairfield, *Freestone*	Travis Peak, Cre L	1945				1,500	684	248		19,500	6,100
34	Flag Lake, *Henderson*	Woodbine, Cre U	1937	405	657,600	5,600	80	x	x			
35	Flower Acres, *Bowie*	Smackover, Jur	1946	x			35	724	365		18,300	8,900
36	Freestone, *Freestone*	L.Gl.Rose(Bodessa), Cre L	1949				40	x	x		x	x
37	Fruitvale, *Van Zandt*	L.Gl.Rose(Pettit), Cre L	1944	80	99,200	11,400	x	x	x		x	x
38	Garrison, *Nacogdoches*	L.Gl.Rose(Pettit), Cre L	1948	80			x	5	5		100	100
39	Ginter, *Angelina*	Carrizo, Eoc	1936	60	66,700	3,700	x	x	x		x	
		Total		1,135	695,500	282,500		x	x		9,791,000	218,000
40	Grapeland, *Houston*	Sub-Clarksville, Cre U	1947	1,135	695,500	282,500		x	x			
		Woodbine, Cre U	1936				6,500	89,925	8,297		9,791,000	218,000
		Total		x	x		x	x	659		x	x
		Nacatoch, Cre U	1913	x	x		2,360	x			x	
41	Greenbeck, *Limestone*	Woodbine, Cre U	1924	x	x		60	x			x	
		L.Gl.Rose(Pettit), Cre L	1939				300	12,398	659		3,000	
42	Greenbeck, South, *Limestone*	L.Gl.Rose, Cre L	1942	5	4,000		x	x				
43	Greenbeck, West, *Limestone*	L.Gl.Rose(Bodessa), Cre L	1944	20	x	x	x	x	x		x	x
44	Ham Gossett, *Kaufman*	L.Gl.Rose(Bacon), Cre L	1948	40	13,800	6,600		x	x			
45	Handy, *Grayson*	Strawn, Pen	1946	140	138,100	56,200		x	x			

LINE NUMBER	NUMBER OF WELLS[a]			WELLS PRODUCING[f] DEC. 1949			RESERVOIR PRESSURE LB PER SQ INCH		SECONDARY RECOVERY[g]	CHARACTER OF OIL[h]		PRODUCING FORMATION					DEEPEST ZONE TESTED[n] TO END OF 1949	
	COMPLETED TO END 1949	1949		OIL		GAS	INITIAL	AVG./END 1949		GRAVITY A.P.I.	SULPHUR PER CENT	CHARACTER[i]	POROSITY PER CENT[j]	DEPTH TO TOP OF PRODUCING ZONE FT.[k]	PROD. THICKNESS AVG. FT.[l] NET	STRUCTURE[m]	NAME	DEPTH OF HOLE, FT
		COMPLETED	ABANDONED	FLOWING	ARTIFICIAL LIFT													
1	23	13			22		x	x		16	4.3	S	22	4,050	10	D	Travis Peak	8,995
2	1				1	1[1]	x	x		39	x	S	P	1,406	10	F	Woodbine	3,093
3	1						x	x		52	x	S	x	8,610	30	A	Travis Peak	9,295
4	10		5		5		1,300	x		42	x	S	23	2,992	15	A F	Woodbine	3,008
	389[2]	7			4	51[3]										A	Eagle Mills	11,303
5	352		2		x		430	x		28	x	S	13	950	x			
	51	7			x	51	2,470	x		x	x	L	20	5,820	x			
6	4			1	3		x	x		24	x	S	x	2,045	5	M L	Carrizo	2,324
7	13	7		11	2		3,870	2,775		44	0.4	L S	P	8,990	11	A	Travis Peak	10,080
8	33				9		1,680	x		38	x	S	25	3,632	34	D S	Fredricksburg	4,648
9	62	37	1	12	50	1	x	x		39	x	S	15	1,500	9	A	Caddo	2,520
10	59		9		5		x	x		41	x	L	P	450	3	A F	Trinity	1,800
11	4				2		x	x		34	x	S	18	7,469	12	A	Paluxy	7,818
12	2	2			2		2,833	x		33	x	S	x	7,485	12	A	Paluxy	7,692
13	16	2		1	2	13	2,589	2,325		26		S	19	5,600	30	D	Travis Peak	10,802
14	30				22	2	x	x		35	0.1	S	x	2,181	12	F	Edwards	5,022
15	10						1,950	x		41	x	S	x	450	3	A F	Trinity	1,800
16	2				2		1,830	x		32		S	16	4,130	7	A F	Lower Glen Rose	4,800
	557[4]	28	x	21		336										D	Cotton Valley	9,306
	38	3	x	1		37	2,609	1,812		41	x	S	23	5,000	14	D		
	1					1	2,645	x		x	x	L	15	5,185	x	D		
	204	6	x			204	3,138	2,434	C	55	x	O L	17	5,284	20	M C		
17	282	16	x	13		269	3,260	2,633		55	x	O L	16	6,230	40	D		
	32	3	x	7		25	3,350	2,333		64	x	S	15	6,530	8	D		
	312	5	6	27	132	60			C							A F	Trinity	9,085
18	300	5	6	25	132	50	1,750	845		28	x	S	25	3,840	Okl-24 Kans-54			
	12			1		10	3,525	1,374		56	x	O L	20	7,600	10			
19	1			1			x	x		30	x	L	x	7,924	x	x	Lower Glen Rose	7,612
20	2				2		x	x		37	x	S	25	2,885	10	A F	Woodbine	3,310
	85[5]	2		39	8	28											Cotton Valley	13,107
	12				1	11	2,574	2,094	C	74	0.1	S	23	5,800	50	A F		
21	10	2		1		9	3,700	1,800		61	0.2	O L	14	7,400	12	A		
	60			36	7	8	4,076	x		43	0.4	O L	10	8,000	10	A		
	3			2			3,840	x		51	x	S	P	8,100	10	A		
	86	25		15	70											D	Travis Peak	9,644
	54	23			54		x	x		15	x	S	28	4,082	17			
22	29			12	16		2,705	2,637		26	2.3	S	21	6,300	55			
	3	2		3		0[6]	3,660	3,226		42	x	L	14	8,080	40			
23	4				3	1	x	x		29	x	S	x	3,840	20	M L	Strawn	4,219
24	38	16			38		1,600	1,150		22	x	S	19	4,185	7	A	Travis Peak	8,642
25	1,442		41		505		x	x		27	x	S	x	800	16	A F	Woodbine	3,570
26	55				11		x	x		42	x	S	22	2,930	20	A F	Woodbine	3,646
27	22						757	x		46	x	S, Sh	x	1,990	x	M L	Blossom	2,125
28	28,336	469	504	12,414	9,803		1,620	1,030	e	39	x	S	25	3,600	39	T M	Paluxy	5,030
29	6	2				6	2,200	x		x	x	S	25	5,450	30	F A	Woodbine	5,763
30	1			1			x	x		x	x	S	x	6,294	14	x	Travis Peak	6,851
31	1				1		3,550	x		40	x	O L	x	7,658	30	F A	Smackover	7,836
32	1					1												
33	2	1				2	3,778	x		x		S	15	8,230	20	A	Travis Peak	14,331
34	26	3	1		8	2	1,394	x		45	x	S	23	3,075	5	A F	Travis Peak	6,518
35	1					1	3,152	2,390		74	x	O L	7	7,038	50	x	Smackover	7,095
36	1					1	3,940	3,940		x	x	L	x	8,315	85		Smackover	16,347
37	2				2		x	x		39	x	S	x	8,550	18	D	Travis Peak	9,002
38	1					1	3,199	x		x	x	L	x	7,109	10	A	Travis Peak	7,866
39	4			2	2		x	x		21	x	S	x	2,186	10	M L	Wilcox	2,265
	87	9	4	19	6	43											Travis Peak	11,078
40	40	9		19	6		x	x		45		S	20	5,550	5	D		
	47		4			43	2,535	2,150	C	x		S	20	5,900	24	A D		
	43					x										F	L.Gl.Rose (Pettit)	5,786
	30						275	x		x	x	S	25	710	40			
41	5					x	375	x		x	x	S	20	2,945	15			
	6					4	2,659	420		x		L	15	5,650	40			
42	1						x	x		x	x	x	x	x	x			
43	1				x		x	x		41	x	L	x	4,734	54	F	L.Gl.Rose (Pettit)	5,515
44	2				2		1,223	x		38		O L	x	6,132	5	S T	Travis Peak	6,956
45	7			4	3		950	870		40	x	S	25	1,670	40	F A	Pen	5,545
														2,100				

TABLE I - Continued OIL AND GAS PRODUCTION STATISTICS FOR EAST AND EAST CENTRAL TEXAS

LINE NUMBER	FIELD (County)[a]	PRODUCING FORMATION NAME AND AGE[b]	YEAR OF DISCOVERY	OIL PRODUCTION			GAS PRODUCTION			GAS/OIL RATIO[d] MCF/BBL	CONDENSATE PRODUCTION Thousands of Bbl	
				AREA PROVED ACRES	BARRELS TO END OF 1949	BARRELS DURING 1949	AREA PROVED ACRES	MILLION CU FT[c] TO END OF 1949	MILLION CU FT[c] DURING 1949		TO END OF 1949	DURING 1949
		Total		8,400	107,842,200	11,453,900	8,460	39,482	4,018		16,000	
		Sub-Clarksville, Cre U	1940				4,700	1,836			16,000	
46	Hopkins, *Wood*	Woodbine, Cre U	1940	8,400	107,842,200	11,453,900	3,600	37,646	4,018			
		L.Gl.Rose(Rodessa),Cre L	1947				160					
47	Henderson, *Rusk*	Total,[f] Cre L	1943	3,200	1,326,200	263,200	1,200	7,316	287		61,400	6,400
48	Henderson, South, *Rusk*	Travis Peak, Cre L	1946				80	16			500	
49	Honest Ridge, *Limestone*	Woodbine, Cre U	1946	40	8,600	1,600	x	x	x			
50	Huntington, *Angelina*	Queen City, Eoc	1936	100	18,600	600	x	x	x			
		Total		40	1,100	1,100	1,400	637	166		9,400	2,400
51	Huxley, *Shelby*	L.Gl.Rose(Rodessa),Cre L	1949	40	1,100	1,100		1	1			
		L.Gl.Rose(Pettit),Cre L	1946				1,400	636	165		7,000	2,400
52	Joaquin,[g] *Shelby*	L.Gl.Rose(Pettit),Cre L	1931				10,000	60,582	11,693		322,600	15,600
53	Kildare, *Cass*	L.Gl.Rose(Gloyd), Cre L	1942	1,500	2,222,100	123,100	x	x	x		4,000	
54	Kosse, *Limestone*	x	1922	10	33,000			x				
55	Lakeview, *Franklin*	Paluxy, Cre L	1949	80	24,400	24,400		x	x			
56	Larissa, *Cherokee*	L.Gl.Rose(Pettit),Cre L	1942	60	61,200	6,200	200	x	21			
57	La Rue, *Henderson*	L.Gl.Rose(Bacon), Cre L	1945	500	575,500	104,700		733	153			
		Total		40	7,500		1,920	1,517	1,073		103,200	74,200
58	Lassater, *Marion*	Travis Peak, Cre L	1946	40	7,500		640	530	258		21,200	8,200
		Cotton Valley, Jur	1948				1,280	987	815		82,000	66,000
59	Lone Star, *Cherokee*	Nacatoch, Woodbine, Cre U	1938	320	703,100	74,500	x	x	x			
60	Long Lake, *Leon, Anderson, Freestone*	Woodbine, Cre U	1933	15,680	17,068,200	1,220,100	15,680	220,901	19,002		9,245,100	36,000
61	Long Lake, East, *Anderson*	Woodbine, Cre U	1941	1,143	1,993,000	228,300	1,213	1,647	606		1,800	800
		Total		280	89,000	45,000	x	x	x		x	x
		Goodland, Cre L	1948	120	10,000	7,000	x	x	x		x	x
62	Longwood, *Harrison*	L.Gl.Rose(Pettit),Cre L	1936	120	57,000	30,000	160	242	67		x	200
		Travis Peak, Cre L	1948	40	22,000	8,000	x	x	x		x	x
63	Lott, *Falls*	Hosta(L.Washita),Cre L	1937	100	35,300	2,300	x	x	x			
		Total		2,134	4,197,100	625,100	160	1,198	502		48,100	10,000
		Sub-Clarksville, Cre U	1946	800	539,700	124,100	x	x				
		Woodbine, Cre U	1946	40	6,000			x				
64	Manziel, *Wood*	Paluxy, Cre U	1943	1,134	3,572,100	501,000		x	x			
		L.Gl.Rose(Rodessa),Cre L	1944	80	12,000	8,000	160	1,397	426		48,100	10,000
		Travis Peak, Cre L	1944	80	67,300	3,000		x	x			
65	Marion, *Marion*	Tokio, Cre U	1939	670	869,200	51,600	x	x	x			
66	Marlin-Satin, *Falls*	Hosta, Cre L	1931	10	13,000			x				
67	Marshall, *Harrison*	L.Gl.Rose(Pettit),Cre L	1945				400	175	29		2,500	500
68	Maydelle, *Cherokee*	L.Gl.Rose(Bacon), Cre L	1947				640	286	10		x	100
		Total		1,600	3,813,200	966,700		x	x			
69	Merigale Paul, *Wood*	Sub-Clarksville, Cre U	1944	1,590	3,743,900	984,800		x	x			
		Woodbine, Cre U	1946	10	69,300	11,900		x	x			
		Total		3,920	101,632,200	378,600	x	x	x			
70	Mexia, *Limestone*	Nacatoch, Cre U	1912				4,094	x	x			
		Woodbine, Cre U	1920	3,920	101,632,200	378,600	x	x	x			
71	Maneola, *Wood*	Sub-Clarksville, Cre U	1949	40	1,500	1,500		x	x			
72	Mitchell Creek, *Hopkins*	Paluxy, Cre L	1948	200	105,200	85,100		x	x			
73	Mount Calm, *Hill*	Austin, Cre L	1929	x	28,000	x	x	x	x			
74	Mount Sylvan, *Smith*	Paluxy, Cre L	1946	100	315,100	70,900		50	11			
75	Myrtle Springs, *Van Zandt*	Travis Peak, Cre L	1945	80	20,000		x	x				
76	Nacogdoches, *Nacogdoches*	Weches, Eoc	1865	1,000	438,000		x	x	x		x	
77	Navarro Crossing, *Houston*	Woodbine, Cre U	1938	825	1,337,400	73,600	3,700	27,386	3,430		57,700	14,500
		Total		12,087	9,012,300	1,876,200	12,087	3,584	542			
		L.Gl.Rose(Bacon), Cre L	1943	4,610	2,947,600	827,000	4,610	669	194			
		L.Gl.Rose(Hill), Cre L	1944	1,284	2,567,100	547,700	1,284	608	135			
78	New Hope, *Franklin*	Travis Peak(Pittsburg), Cre L	1943	3,304	3,135,500	484,000	3,303	1,326	200			
		Travis Peak(Elledge), Cre L	1944	2,890	362,200	17,500	2,890	981	13			
79	Nigger Creek, *Limestone*	Woodbine, Cre U	1926	170	2,999,000		x	x				
80	Nolan Edwards, *Wood*	Sub-Clarksville, Cre U	1949	120	38,700	38,700		1	1			
81	Normangee-Flynn, *Leon*	Woodbine, Cre U	1946	20	11,900	2,700	x	x	x		x	x
82	North Lansing, *Harrison*	L.Gl.Rose(Rodessa),Cre L	1949				40	3	3		43	43
		Travis Peak, Cre L										
83	Oakwood, *Leon*	Woodbine, Cre U	1939	80	14,000		2,390	7,109	2,013		62,400	15,500

LINE NUMBER	NUMBER OF WELLS[e]			WELLS PRODUCING[f] DEC. 1949			RESERVOIR PRESSURE LB PER SQ INCH		SECONDARY RECOVERY[g]	CHARACTER OF OIL[h]		PRODUCING FORMATION					DEEPEST ZONE TESTED[m] TO END OF 1949	
	COMPLETED TO END 1949	1949 COMPLETED	1949 ABANDONED	OIL FLOWING	OIL ARTIFICIAL LIFT	GAS	INITIAL	AVG./END 1949		GRAVITY A.P.I.	SULPHUR PER CENT	CHARACTER[i]	POROSITY PER CENT[j]	DEPTH TO TOP OF PRODUCING ZONE FT.[k]	PROD. THICKNESS AVG. FT.[l] NET	STRUCTURE[n]	NAME	DEPTH OF HOLE, FT
	638	9		556	65	1										A F	Stuckover	14,629
	1						1,823	1,656		x	x	S	x	3,790	80			
46	636	9		556	65		▶ 1,990	1,656		25	2.1	S	27	Gas 3,910	107			
							◀ 1,710	1,603						Oil 4,475				
	1					1	3,495	x		51		L	x	8,970	35			
47	35			32	1	2	3,521	x		43	x	S,O L	12	7,450	12	A L	Travis Peak	7,642
48	1[8]			1			1,985	x		61	x	S	x	7,316	15	A	Travis Peak	7,519
49	2	1			2		x	x		36	x	S	x	2,905	15	A F	Woodbine	3,014
50	12				1		x	x		24	x	S	x	1,458	8	M L	Mt. Selman	1,490
	5	1			1	4										A	Stuckover	12,221
51	1				1		2,640	x		39	x	L	x	5,317				
	4	1				4	3,466	x		57		L	16	6,800	20			
52	34	4				26[10]	2,740	x	C	48		L	16	4,975	44	A	Travis Peak	6,225
							3,230							6,300	15			
53	35			7	21		2,750	x		41	x	L	16	5,973	15	A F	Dees-Young	6,205
54	1						x	x		32	x	x	x	x	x	x	Glen Rose	6,056
55	3	3			3		1,600	x		23	x	S	x	4,399	5		Paluxy	4,417
56	1			1			5,125	x		48		L	x	10,600	52	A D	Travis Peak	10,604
57	10			2	4		3,773	x		43		L	19	8,200	12	A	Travis Peak	9,242
	4	1				3										D	Cotton Valley	10,518
58	2					1	3,800	x		60	x	S	13	8,736	12			
	2	1				2	4,245	3,985		66	x	S	13	9,025	15			
59	8		1		7		1,375	x		41	x	S	x	3,348	4	A F	Travis Peak	8,370
										35				4,006				
60	228	8	4	75	54	73	2,440	1,841	C	41	x	S	25	5,200	Oil- 8	A F	Trinity	10,681
															Gas-24			
61	21	1	1	7[11]	12	5	Gas 2,175	x	W	45		S	23	Gas 5,340	Gas-11	D	Woodbine	5,910
							Oil 2,200							Oil 5,380	Oil- 8			
	13	2	2	3	4	1										T	Cotton Valley	8,322
	4				3		x	x		29	x	C	x	2,440	12			
62	5	2	1	2	1	1	2,100	x		39	x	L	16	5,578	24			
	4		1	1			x	x		42	x	S	x	5,924	8			
63	5				1		x	x		29	x	O L	x	1,250	10	A F	Edwards	1,500
	63	2		15	39	2										A F	Travis Peak	9,297
	22	1			20		x	x		16	3.7	S	P	4,130	24			
	1						x	x		26	x	S	P	4,774	5			
64	33			14	19		2,710	x		32	L.7	S	20	6,308	20			
	5	1		1		2	x	x	Good	65	x	L S	P	8,393	45			
									Oil	45								
	2		1	1			x	x		43	x	S	P	8,742	20			
65	68		x		48		x	x		42	x	S	x	2,236	10	A	Tokio	2,346
66	2						x	x		34	x	L	20	1,000	20	A F	Glen Rose	1,429
67	1					1	2,056	x		x	x	L	x	6,471	30	A	Travis Peak	7,027
68	2	1				2	4,223	x		56	x	L	17	8,608	50	A	Travis Peak	10,016
	169	38		5	162											M F	Paluxy	7,386
69	168	28		5	161		2,043	578		26	x	S	20	4,806	23			
	1				1		x	x		16	x	S	15	5,237	31			
	601	10			125	8										A F	Cotton Valley	8,847
70	50					8	276	x		x	x	S	25	710	40			
	551	10			125		x	x		36	x	S	25	3,000	50			
71	1	1			1		x	x		18	x	S	x	4,618	36		Sub-Clarksville	4,743
72	7	3			7		1,887	x		16	3.6	S	25	4,500	25	M F	Paluxy	4,700
73	2				1		x	x		31	x	C	x	607	8	F	Travis Peak	3,398
74	3				3		3,266	2,193		34	0.4	S	24	7,665	19	M C	Paluxy	7,668
75	2						3,586	x		36	L 5	S	12	8,525	10	A	Travis Peak	8,906
76	50						x	x		23	x	S	x	80	x	A	Cre L	5,484
77	36			12	7	17	2,700	2,457		35	x	S	23	5,900	7	A F	Woodbine	6,099
	112	2	1	47[12]	24											A	Travis Peak	8,707
	35	1		24	7		3,425	2,766	W	44	x	O L	19	7,300	11			
	21	1	1	14	1		3,425	2,894	W	45	x	S	17	7,400	14			
78	41			9	15		3,523	2,026	W	47	x	S	13	7,900	17			
	15				1		3,741			52	x	S	11	8,200	3			
79	75						x	x		40	x	S	25	2,820	15	A F	Woodbine	3,509
80	5	5			5		x	x		18	x	S	x	4,993	22		Woodbine	5,594
81	4			1			x	x		34	x	S	x	7,160	10	M C	Edwards	7,303
82	1[13]	1[13]				2	2,734	x		53	x	L	x	6,734	32		Travis Peak	8,000
												S		7,394				
83	11	1				11	2,700	2,449		51	x	S	22	5,850	25	A F	Woodbine	6,208

TABLE 1 - Continued OIL AND GAS PRODUCTION STATISTICS FOR EAST AND EAST CENTRAL TEXAS

LINE NUMBER	FIELD (County)[a]	PRODUCING FORMATION NAME AND AGE[b]	YEAR OF DISCOVERY	OIL PRODUCTION			GAS PRODUCTION			GAS/OIL RATIO[d] MCF/BBL	CONDENSATE PRODUCTION Thousands of Bbl	
				AREA PROVED ACRES	BARRELS TO END OF 1949	BARRELS DURING 1949	AREA PROVED ACRES	MILLION CU FT[c] TO END OF 1949	MILLION CU FT[c] DURING 1949		TO END OF 1949	DURING 1949
		Total		4,000	2,169,000	740,000	16,500	57,948	5,600		10,196,000	834,000
84	Quelika, *Henderson*	U.Gl.Rose, Cre L L.Gl.Rose(Rodessa),Cre L L.Gl.Rose(Pettit),Cre L Travis Peak, Cre L	1937 1937 1945 1938	4,000	2,169,000	740,000	9,000 2,500 5,000	38,603 3,897 15,448	1,010 694 3,896		9,943,000 65,000 188,000	777,000 14,000 43,000
85	Quelika-Peacock, *Henderson*	L Gl.Rose(Rodessa),Cre L	1940				700	15,830	393		535,000	16,000
86	Orr, *Denton*	Strawn, Pen	1948				20					
87	Patroon, *Shelby*	L. Gl. Rose, Cre L	1948	160	10,600	5,900		62	20			
88	Percilla, *Houston*	Woodbine, Cre U		10	30,000		500	4,274	600e		114,600	19,800
89	Pewitt Ranch, *Titus*	Paluxy, Cre L	1949	120	19,900	19,900		4	4			
90	Pickering, *Shelby*	Nacatoch, Cre U	1941	20	1,000			x	x			
91	Pickton, *Hopkins*	L.Gl.Rose(Bacon),Cre L	1944	2,800	2,206,800	301,000		4,818	857			
92	Pine Mills, *Wood*	Sub-Clarksville, Cre U	1949	80	13,400	13,400		5	5			
93	Pittsburg, *Camp*	Travis Peak(Pittsburg), Cre L	1940	4,500	1,987,100	142,000		x	x			
		Total		240	642,000	59,400		x	x			
94	Pleasant Grove, *Rusk*	Nacatoch, Cre U Woodbine, Cre U	1941 1941	40 200	50,800 591,300	6,800 52,600		x x	x x			
95	Post Oak (Chilton), *Falls*	Buda, Cre U	1922	100	179,000			x				
96	Potter (Caddo), *Marion*	Nacatoch, Tokio, Cre U	1905	980	7,838,300	20,500		x	x			
97	Pottsboro, *Grayson*	Basal Trinity, Cre L	1928	200	13,000			x				
98	Powell, *Navarro*	Woodbine, Cre U	1923	120	114,744,600	358,600		x	x			
		Total		4,620	16,783,300	2,890,500		x	x			
		Sub-Clarksville, Cre U	1947	500	255,000	142,800		x	x			
99	Quitman, *Wood*	Eagleford, Cre U	1945	1,600	1,869,800	759,800		x	x			
		Woodbine, Cre U	1948	20	44,100	34,900		x	x			
		Paluxy, Cre L	1942	2,500	14,614,500	1,953,100		x	x			
100	Redland, *Angelina*	Wilcox, Eoc	1939	10	500			x	x			
101	Red Lake, *Freestone*	Woodbine, Cre U	1934				320	3,930	247		4,000	200
102	Red Springs, *Smith*	L.Gl.Rose(Rodessa),Cre L	1949	80	73,200	73,200	320	56	56		4,100	4,100
103	Reed (Moody), *Freestone*	Woodbine, Cre U	1947	0[14]	10,600	200	2,400	670	540		6,500	6,500
104	Richland, *Navarro*	Woodbine, Cre U	1924	234	6,736,700	8,900	x	x	x			
105	Richland, New, *Navarro*	L.Gl.Rose(Rodessa),Cre L	1946	40	3,000	1,000	x	x	x			
		Total		4,495	60,475,000	949,000	17,830	287,605	16,781		x	129,900
		Cass L.Gl.Rose (Dees-Young), Cre L	1935									28,600
		Cass L.Gl.Rose(Hill-Gloyd), Cre L	1936	4,035	60,066,000	782,000	10,150	262,983	7,238		x	24,600
106	Rodessa,	Marion L.Gl.Rose(Hill-Henderson Gloyd), Cre L	1937									42,500
		Cass, Marion L.Gl.Rose(Pettit),Cre L	1947	360	323,000	123,000	2,560	15,153	4,725		x	20,800
		Marion Travis Peak	1945	100	86,000	44,000	5,120	9,469	4,818		x	13,300
107	Rose & Baker, *Henderson*	Woodbine, Cre U	1939	80	82,000			x				
108	Rusk, *Cherokee*	Woodbine, Cre U	1934	200	261,000			x				
109	Sadler, *Grayson*	Strawn, Pen	1943	20	1,000			x				
110	San Augustine, *San Augustine*	L.Gl.Rose(Pettit),Cre L	1947	80	11,100	1,100	80	85	30		x	x
		Total		2,280	2,560,700	544,900		413	125			
111	Sand Flat, *Smith*	Paluxy, Cre L	1944	2,200	2,543,600	542,100		366	108			
		L.Gl.Rose(Rodessa),Cre L	1944	80	17,100	2,700		47	17			
112	Scottsville, *Harrison*	Travis Peak, Cre L	1947	40	7,300	1,500	x	x	x		x	x
113	Sessions, *Cherokee*	Woodbine, Cre U	1948	x			200					
114	Shelbyville, *Shelby*	Blossom, Cre U	1917	50	25,700	1,300		x	x			
115	Sherman Area, *Grayson*	Strawn	1947	x	1,506,500	1,031,900		x	x			
116	Sherman, East, *Grayson*	Strawn	1949	160	30,700	30,700		x	x			
117	Southern Pine, *Cherokee*	Woodbine, Cre U	1948	40	3,600	1,300		x	x			
118	Steward's Mill, *Freestone*	Woodbine, Cre U	1943				320	930	161		15,500	7,300
119	Stony Point (League), *Freestone*	L.Gl.Rose(Pettit),Cre L	1945				1,300	1,050	952		2,500	2,100
120	Sulphur Bluff, *Hopkins*	Paluxy, Cre L	1936	795	17,605,600	730,500	x	x	x			
121	Tacoma, *Panola*	Blossom, Cre U	1933	40	16,000			x				
122	Talco, *Franklin, Titus*	Paluxy, Cre L	1936	8,500	116,821,800	6,164,700		2,335	123			
123	Tehuacana, *Limestone*	Woodbine, Cre U	1940	60	74,300	4,800		x	x			
124	Tennessee Colony, *Anderson*	L.Gl.Rose(Rodessa),Cre L	1949	40	3,700	3,700	x	11,182	11,182		1,400	1,400
125	Trawick, *Nacogdoches*	L.Gl.Rose(U. Pettit), Cre L	1949				2,200	100	100		600	600
		Total		1,420	1,301,000	341,000	7,450	25,807	3,007		826,000	13,900
		L.Gl.Rose(Bacon),Cre L	1941	40	14,000	8,000	3,150	19,953	960		813,000	3,900
126	Tri-Cities, *Henderson*	L.Gl.Rose(Rodessa),Cre L	1946	1,340	1,284,000	331,000	1,340	5,769	1,995		12,000	9,000
		L.Gl.Rose(Pettit),Cre L	1948	40	3,000	2,000	360	85	52		1,000	1,000
		Travis Peak	1947				2,600					
127	Trinity (Kittrell), *Houston*	Carrizo, Eoc	1934	120	2,932,100	120,400		x	x			
128	Tundra, *Van Zandt*	L.Gl.Rose(Rodessa),Cre L	1944	40	19,100	4,200		x	x			
129	Tyler, *Smith*	Paluxy, Cre L	1948	160	89,300	81,600		2	1			

LINE NUMBER	NUMBER OF WELLS[c]			WELLS PRODUCING[f] DEC. 1949			RESERVOIR PRESSURE LB. PER SQ. INCH		SECONDARY RECOVERY[g]	CHARACTER OF OIL[b]		PRODUCING FORMATION					DEEPEST ZONE TESTED[n] TO END OF 1949	
	COMPLETED TO END 1949	1949		OIL		GAS	INITIAL	AVG./END 1949		GRAVITY A.P.I.	SULPHUR PER CENT	CHARACTER[i]	POROSITY PER CENT[j]	DEPTH TO TOP OF PRODUCING ZONE FT.[k]	PROD. THICKNESS AVG. FT.[l] NET	STRUCTURE[m]	NAME	DEPTH OF HOLE, FT.
		COMPLETED	ABANDONED	FLOWING	ARTIFICIAL LIFT													
	70	16	1	44		25										F D	Travis Peak	10,100
84	63	16		44		19	3,900	x	C	45		L	16	(Gas-8,200 Oil-8,800	40 7			
	3		1			2	4,546	x		x		L	16	9,300	25			
	4					4	4,156	x		x	x	S	16	9,600	1,400			
85	2		1			1	3,780	2,838		x	x	L	18	8,012	39	D	Travis Peak	9,655
86	1					1	925	x		x	x	L	x	1,990	14	A	Ellenberger	2,323
87	1			1			2,190	1,500e		31	x	L	x	5,220	x		Travis Peak	9,302
88	5		x			2	x	x		41	x	S	x	5,665	5	A	Del Rio	6,634
														5,932	6			
89	4	4			4		x	x		19	x	S	x	4,505	29		Upper Glen Rose	5,539
90	1						x	x		40	x	S	x	1,475	20	M L	Washita	3,343
91	54	8		53	1		3,578	3,230	G	51	0.4	O L	18	7,900	14	A	Travis Peak	8,853
92	4	4		4			x	x		27	x	S	x	4,792	13		Sub-Clarksville	4,792
93	26				23		3,408	x		39	x	S	16	7,948	20	D	Eagle Mills	13,373
	10	7			8											F	Woodbine	4,332
94	2	1			2		x	x		35	x	S	x	2,910	25			
	8				6		x	x		40	x	S	20	4,055	5			
95	26						x	x		33	x	L	x	1,025	10	A F	Trinity	3,567
96	77		x		69		x	x		40	x	S	x	1,025	x	A	Tokio	2,400
													20	2,300	15			
97	15						300	x		39	x	S	x	830	8	M U	Ordovician	6,004
98	772		1		126		800	x		38	x	S	25	2,925	40	A F	Trinity	6,506
	149	11	2	55	87											A F	Cotton Valley	11,258
	18	4			14		x	x		16	x	S	20	3,930	10			
99	53	5	2		51		1,900	x		25	2.3	S	27	4,120	10			
	1				1		x	x		15	x	S	P	4,350	9			
	77	2		55	21		2,745	2,580		41	1.1	S	21	6,250	35			
100	1						x	x		23	x	S	x	1,021	8	M L	Wilcox	1,032
101	3		1			1	1,860	1,200		x	x	S	23r	4,900	42	A F	Woodbine	4,954
102	4	4		2		2	5,825	4,300		44	x	L	x	9,370	36		Travis Peak	10,409
103	7	3			1	2	1,680	1,538		41		S	20	4,200	10	A	Travis Peak	14,331
104	112				4		x	x		38	x	S	25	2,975	20	A F	Glen Rose	5,414
105	2				2		x	x		x	x	x	x	x	x	x	x	x
	597	x	x	19	208	57										A F	Salt	11,484
106	571	x	x	16	201	41	2,677	x	P	42	x	S L	15	6,044	20			
	16	1		2	7	7	2,710	x		45	x	L	16	6,432	30			
	10	5		1		9	3,100	x		x	x	S	16	7,010	22			
107	4						x	x		32	x	S	30	3,140	6	A F	Woodbine	3,149
108	5						x	x		42	x	S	20	5,120	10	M U	Woodbine	5,302
109	1						x	x		25	x	S	x	7,160	10	M	Simpson	8,403
110	3		1				5,000	x		48	x	L	5	8,150	5	A	Travis Peak	8,977
	54			2	52											A F	Travis Peak	10,011
111	52				52		2,925	849		28	2.1	S	21	7,400	19			
	2			2			4,201	1,500e		41	0.4	L	x	9,264	20			
112	1				1		2,362	x		40	x	S	13	6,445	11	T F	Travis Peak	6,785
113	2					2	1,590	x		x	x	S	x	4,273	5	A	Woodbine	4,398
114	2				1		x	x		38	x	S L	x	3,196	10	M L	Georgetown	3,530
115	41	37		2	39		1,930	x		39	x	S	19	4,350	21	A	Strawn	6,050
116	10	10			10		x	x		39	x	S	x	3,348	40	x		
117	1				1		x	x		24	x	S	x	5,250	3	x	Woodbine	5,450
118	2	1				2	1,605	1,458		x	x	S	20	3,990	6	F D	Travis Peak	8,150
119	3	1				2	3,665	3,362		49		L	P	7,970	25	A	Travis Peak	8,541
120	73		1		64		1,900	x		23	x	S	25	4,500	42	A F	Smackover	9,513
121	3						x	x		46	x	S	x	2,073	10	M L	Blossom	2,302
122	889	10			731		1,920	1,000e		24	x	S	20	4,200	35	A F	Smackover	9,048
123	8				3		x	x		21	x	S	x	2,640	10	A F	Georgetown	2,825
124	1[15]			1		1	2,959	x		46	x	L	x	8,865	20	A	Travis Peak	10,182
										57				8,965				
125	1	1				1	3,984	x		48	x	L	x	7,498	36	A	Transition Zone	7,911
	49	1		26	2	16										A F	Travis Peak	8,750
	18			1		13	3,692	500		49		L	x	7,580	10			
126	29			25	2	2	3,730	1,250		46		L	12	7,700	15			
	2	1				1	3,900	x		45		L	x	8,220	15			
							3,930	3,930		x	x	L	x	8,600	40			
127	20		x		15		870	x		24	x	S	25	1,987	25	D S	Wilcox	5,500
128	1				1		870	x		42	0.2	L	P	8,146	8	A	L.Gl.Rose (Fredessa)	8,373
129	4	3		1	3		3,750	x		27	x	Sh	x	7,572	5	A	Palury	7,890

TABLE I - Continued OIL AND GAS PRODUCTION STATISTICS FOR EAST AND EAST CENTRAL TEXAS

LINE NUMBER	FIELD (County)[a]	PRODUCING FORMATION NAME AND AGE[b]	YEAR OF DISCOVERY	OIL PRODUCTION			GAS PRODUCTION			GAS/OIL RATIO[d] MCF/BBL	CONDENSATE PRODUCTION Thousands of Bbl	
				AREA PROVED ACRES	BARRELS TO END OF 1949	BARRELS DURING 1949	AREA PROVED ACRES	MILLION[c] CU FT TO END OF 1949	MILLION[c] CU FT DURING 1949		TO END OF 1949	DURING 1949
130	Tyler, South, *Smith*	Total		x	x	x	960	7,581	2,317		57,000	57,000
		L.Gl.Rose(Hosdessa),Cre L	1949	x	x	x	480	1,156	1,156		57,000	57,000
		L.Gl.Rose(James),Cre L	1944	480	345,000	51,000	480	6,425	1,161		x	x
131	Van, *Van Zandt*	Total		4,560	203,516,900	8,300,200		x	x			
		Nacatoch, Cre U	1933	200	501,000	26,300		x	x			
		Woodbine, Cre U	1929	4,360	203,015,900	8,274,900		x	x			
132	Walter Fair, *Kaufman*	Paluxy, Cre L	1949	160	32,300	32,300		x	x			
		Total		1,740	564,000	158,800	61,400	110,044	27,584		1,846,000	372,000
		Nacatoch Blossom, Cre U	1924	400								
		L.Gl.Rose (Hall),Cre L	1937	500			5,300	9,278	3,186			
133	Waskom, *Harrison*	L.Gl.Rose(L.Pettit),Cre L	1945	40	564,000	158,800	24,600	24,544	13,173		1,846,000	372,000
		L.Gl.Rose(L.Pettit),Cre L	1945	x								
		Travis Peak, Cre L	1939	800			31,500	76,222	11,225			
134	Weches, *Houston*	Woodbine, Cre U	1948	240	91,800	3,200	x	x	x			
		Total					9,548	68,683	30,979		632,700	125,500
135	Whelan (Harleton), *Harrison*	L.Gl.Rose(Hosdessa),Cre L	1945				6,036	x	x		x	x
		Travis Peak	1945				3,512	x	x		x	x
136	Wieland, *Hunt*	Woodbine, Cre U	1942	160	940,600	121,300	x	x	x		x	x
137	William Wise, *Cherokee*	Woodbine, Cre U	1946	150	352,600	89,900		x	x			
		Total					6,500	78,000	8,000		866,500	64,100
		L.Gl.Rose(Hosdessa),Cre L	1938									
138	Willow Springs, *Gregg*	L.Gl.Rose(U.Pettit),Cre L					6,500	78,000	8,000		866,500	64,100
		L.Gl.Rose(L.Pettit),Cre L										
139	Winnsboro, *Wood*	L.Gl.Rose(Hosdessa),Cre L	1944	985	886,100	58,200	856	4,745	2,280		224,300	117,700
140	Witherspoon, *N. Fee*	Nacatoch, Cre U	1915	400	810,000			x				
141	Woodlawn, *Harrison*	L.Gl.Rose(Pettit),Cre L	1947				2,560	140	125		7,500	7,300
		Total	1924	715	23,564,200	80,500	x	x	x			
142	Wortham, *Freestone*	Nacatoch, Cre U										
		Woodbine, Cre U										
		Total			477,000	288,500		2,441	2,149		160,900	139,600
143	Yantis, *Wood*	Eagleford, Cre U	1948		477,000	288,500		x	x			
		L.Gl.Rose(Hosdessa),Cre L	1947					2,441	2,149		160,900	139,600
	Grand Total - East and East Central Texas:			258,112	3,591,973,700	139,695,800	667,188	3,156,126	721,937		52,759,000	5,773,302

[1] Gas well shut in.
[2] Total sand wells.
[3] Total sand wells. Includes ten dual completions, 21 single completions, and ten dry gas wells dead.
[4] Total 257 holes, of which 200 are dually completed. Number wells for each zone are wells in sand.
[5] Includes seven dual completions.
[6] Discovery well originally completed as gas well.
[7] Includes Lower Glen Rose (Pettit) and Travis Peak production.
[8] Converted to oil well in 1949.
[9] Extends into Louisiana; data for Texas part only.
[10] Includes two dual completions.
[11] Includes four dual oil-gas wells and one dual oil well.
[12] Includes 37 single oil wells and 14 dual oil wells.
[13] Dual completion.
[14] Moody 1 completed as an oil well, reclassified as gas well after producing small amount of oil.
[15] One dual completion.

LINE NUMBER	NUMBER OF WELLS[e]			WELLS PRODUCING[f] DEC. 1949			RESERVOIR PRESSURE LB PER SQ INCH		SECONDARY RECOVERY[g]	CHARACTER OF OIL[h]		PRODUCING FORMATION					DEEPEST ZONE TESTED[m] TO END OF 1949	
	COMPLETED TO END 1949	1949		OIL		GAS	INITIAL	AVG.-/END 1949		GRAVITY A.P.I.	SULPHUR PER CENT	CHARACTER[i]	POROSITY[j] PER CENT	DEPTH TO TOP OF PRODUCING ZONE FT[k]	PROD. THICKNESS AVG. FT[l] NET	STRUCTURE[n]	NAME	DEPTH OF HOLE, FT
		COMPLETED	ABANDONED	FLOWING	ARTIFICIAL LIFT													
130	8		2	3		4[15]										A	Cotton Valley	13,781
	4			3			4,316	x		57	x	L	x	9,553	20			
	4		2			4	6,500	x		x	x	L	16	9,870	20			
	637	3	1	260	325											A F	Travis Peak	7,501
131	51	3	1		32		x	x		32	x	S	P	1,161	10			
	586			260	293		1,230	812		34	x	S	P	2,224	129			
132	6	6		3	3		2,300	x		30	x	S	x	4,965	18	F	Paluxy	4,987
	108	24		26	2	80										A	Travis Peak	6,490
							x	x		x	x	x	x	x	x			
	17	7		9		8	2,268	1,943		59	x	S	15	4,900	15			
133	37	4		1		36	2,430	1,965		59	x	L	14	5,600	12			
							2,600	2,339		59	x	L	14	5,700	6			
	54	13		16	2	36	2,660	2,157		59	x	S	13	6,020	45			
134	8	7		5	3		x	x		25	x	S	x	5,742	x	x	Woodbine	5,865
	33	8				32										A	Travis Peak	7,862
135	20	5				20	3,169	x		59	x	O L	18	6,776	22			
	12	3				12	3,179	x		59	x	S	13	7,600	15			
136	7	1			8		1,200	x		37	L0	S	28	2,770	8	F	Salt	9,523
137	8			5	3		900	x		42	x	S	x	5,110	7	M C	Woodbine	5,173
	14		1			12			C							A	Travis Peak	10,384
							2,785	2,450		x	x	L	15	6,600	30			
138	14		1			12	2,960	800		x		L	15	7,200	30			
139	19			9	3	7	Oil- x	x		42		L	21	Oil-8,100	Oil-6	F D	Travis Peak	8,917
							Gas-3,753	2,510						Gas-7,900	Gas-19			
140	85						x	x		19	x	S	14	825	19	A F	Woodbine	3,480
141	4	3				4	3,080	x		62		L	12	6,450	20	A	Cotton Valley	10,374
	341				24		x	x								A F	Glen Rose	4,825
142										29	x	S	x	1,361	6			
										37	x	S	25	2,990	35			
	46	26			41	5										A	Travis Peak	8,512
143	41	22			41		1,804	540		21	x	S	x	4,200	6			
	5	4				5	3,700	3,485		62	x	S L	20	8,510	9			
	33,468	913	595	13,854	13,190	943												

TABLE 4 - ELEVEN MOST PRODUCTIVE FIELDS DURING 1949

FIELD	OIL PRODUCTION 1949				CUMULATIVE PRODUCTION 1-1-50				THOUSANDS BBL DIFFERENCE IN YEARLY PRODUCTION	YEAR OF DISCOVERY	PRODUCING HORIZON
	THOUSANDS OF BBL	PERCENTAGE OF DISTRICT PRODUCTION	PERCENTAGE OF TEXAS PRODUCTION	PERCENTAGE OF U.S.A. PRODUCTION	THOUSANDS OF BBL	PERCENTAGE OF DISTRICT PRODUCTION	PERCENTAGE OF TEXAS PRODUCTION	PERCENTAGE OF U.S.A. PRODUCTION			
East Texas	93,527	67.0	12.5	5.1	2,660,410	74.1	20.5	6.8	-18,353	1930	Woodbine
Hawkins	11,454	8.2	1.5	0.6	107,842	3.0	0.8	0.3	- 6,159	1940	Woodbine
Van	8,300	5.9	1.1	0.5	203,517	5.7	1.6	0.5	- 3,816	1929	Woodbine
Talco	6,165	4.4	0.8	0.3	116,822	3.3	0.9	0.3	- 2,640	1936	Paluxy
Quitman	2,891	2.1	0.4	0.2	16,783	0.5	0.1	x	- 836	1942	Sub-Clarksville, Eagleford, Woodbine, and Paluxy
Cayuga	1,910	1.4	0.3	0.1	43,206	1.2	0.3	0.1	- 106	1934	Woodbine and Rodessa
New Hope	1,876	1.3	0.3	0.1	9,012	0.3	x	x	+ 265	1943	Bacon, Hill, Travis Peak
Long Lake	1,220	0.9	0.2	x	17,068	0.5	0.1	x	- 622	1933	Woodbine
Sherman Area	1,032	0.7	0.1	x	1,506	x	x	x	+ 568	1947	Strawn
Merigale-Paul	997	0.7	0.1	x	3,813	0.1	x	x	- 645	1944	Woodbine
Rodessa (Texas)	949	0.7	0.1	x	60,475	1.7	0.5	0.2	- 182	1935	Dees Young, Hill, Gloyd, Henderson, Travis Peak, Pettit
Total	130,321	93.3	17.4	7.1	3,240,454	90.2	25.0	8.3			
District	139,696		18.7	7.6	3,591,974		27.7	9.2			
Texas	746,244			40.1	12,948,969			33.2			
United States	1,840,688				39,019,219						

x - Less than 0.1 per cent.

TABLE 2 - SUMMARY OF DRILLING OPERATIONS IN EAST AND EAST CENTRAL TEXAS *

IMPORTANT WILDCATS DRILLED IN 1949

LINE NUMBER	FIELD (County)[a]	SURVEY	LEASE AND WELL NO.	TOTAL		COMPLETION		
				FEET	FORMATION	FROM	TO	FORMATION
1	Tennessee Colony, *Anderson*	A. Moore	Royal National Bank #1	10,182	Travis Peak	8,865	8,885	L. Gl. Rose (U. Rodessa)
						8,965	8,990	L. Gl. Rose (L. Rodessa)[a]
2	Lakeview, *Franklin*	S.P. R.R.	Mart Talley #1	4,417	Paluxy	4,412	4,417	Paluxy
3	Freestone, *Freestone*	G. Lamb	H. P. Mc Watters #1	16,347	Buckner	8,315	8,400	L. Gl. Rose (Pettit)
4	East Sherman, *Grayson*	H. Atkinson	Beth Brown #1	4,720	Strawn	3,348	3,450	Strawn
5	North Lansing, *Harrison*	E. A. Merchant	M. P. Tsoe #1	8,090	Travis Peak	6,734	6,740	L. Gl. Rose (Rodessa)[b]
						6,762	6,768	
						6,778	6,793	
6	Walter Fair, *Kaufman*	B. S. Newman	A. G. Wynne #1	4,987	Paluxy	4,965	4,983	Paluxy
7	Transick, *Nacogdoches*	Z. Bennett	Thurman Crawford #1	8,254	Travis Peak	7,496	7,520	L. Gl. Rose (Pettit)[c]
						7,527	7,540	
8	Weiner, *Navarro*	B. B. Newman	W. G. Holloman #1	3,287	Woodbine	3,220	3,226	Woodbine
						3,231	3,237	
9	Bud Lee, *Smith*	J. C. Robertson	E. G. Staples #1	7,692	Paluxy	7,556[d]	7,568[d]	Paluxy
10	Red Springs, *Smith*	Wm. Price	E. W. Winters #1	10,414	Travis Peak	9,368	9,404	L. Gl. Rose (U. Rodessa)
						9,478	9,482	L. Gl. Rose (L. Rodessa)[d]
11	Pewitt Ranch, *Titus*	H. Banks	P. H. Pewitt #1	4,543	Paluxy	4,507	4,532	Paluxy
						4,537	4,541	
12	Coats, *Wood*	J. Stark	B. W. Galbreath #1	5,403	Woodbine	4,508	4,520	Sub-Clarksville
13	Mineola, *Wood*	J. Colson	Joe Carr #1	4,743	Sub-Clarksville	4,612	4,652	Sub-Clarksville
14	Nolan Edwards, *Wood*	S. Yarbrough	Maud Thompson #1	5,594	Woodbine	4,692	4,704	Sub-Clarksville
						4,712	4,724	
15	Pine Mills, *Wood*	D. Gilliland	J. A. Durrett #1	4,806	Sub-Clarksville	4,792	4,806	Sub-Clarksville
16	Long Lake, *Anderson*	S. Sanchez	Joe Monnig #7	9,972	Travis Peak	8,847	8,853	Rodessa
17	Steward's Mill, *Freestone*	J. James	C. B. Robinson #1	8,150	Travis Peak	7,600	7,645	L. Gl. Rose (Pettit)[e]
18	Opelika, *Henderson*	A. Anglin	H. C. Turner #1	9,544	Travis Peak	8,502	8,520	L. Gl. Rose (James Line)
19	Buffalo, *Leon*	A. P. Parker	J. L. Moore Est. #1	5,749	Woodbine	5,709	5,715	Woodbine
20	South Henderson, *Rusk*	J. Smith	C. G. Bayford #1	7,519	Travis Peak	7,237	7,254	L. Gl. Rose (Pettit)
21	Huxley, *Shelby*	R. Marshal	Pickering Lbr. Corp. #F-1	7,393	Travis Peak	5,317	5,331	L. Gl. Rose (Rodessa)
22	South Tyler, *Smith*	M. Long	W. J. Mc Minn #1	10,011	L. Gl. Rose (James Line)	9,550	9,570	L. Gl. Rose (Rodessa)
23	Alba, *Wood*	Mc Mahan	Consumer Lignite Corp. #1	4,748	Woodbine	4,153	4,170	Sub-Clarksville
24	Coke, *Wood*	J. Knight	E. L. Faulk #3	6,380	Rodessa	6,230	6,236	Rodessa
						6,246	6,256	
						6,264	6,340	

Key: C-OF, calculated open flow; P, pumping; x, information not available.
*Discoveries, extensions and important wildcats drilled during 1949.

[a] Dual completion.
[b] Non-commercial gas production discovered in Travis Peak.
[c] Gas in commercial quantities was also discovered in the U. Rodessa and L. Rodessa, and the Pettit-Travis Peak Transition Zone. However, no completions have been made.
[d] E. Winters #1 was originally completed in Lower Zone as gas well, but was re-completed as oil well in Upper Zone.
[e] Gas zone discovered in Lower Glen Rose (Rodessa).
[f] Original completion date. Re-completion date not available.

	PROVEN FIELDS	WILDCATS	TOTAL
Oil wells completed during 1949	775	16	791
Gas wells completed during 1949	46	9	55
All wells completed during 1949	821	25*	846
Dry holes drilled during 1949	107	161	268
Total wells drilled during 1949	928	186	1,114

*Includes 24 surface wells and one gas-oil dual completion.

IMPORTANT WILDCATS DRILLED IN 1949

LINE NUMBER	INITIAL PRODUCTION PER DAY: OIL BBL	GAS MMCF	COND BBL/MMCF	CHOKE - FRACTIONS OF AN INCH	PRESSURE LB/SQ. IN.: CASING	TUBING	DRILLED BY	1949 COMPLETION DATE	REMARKS
1	108.5	0.208		1/2	750	x	Continental	11-19	Discovery Well, Tennessee Colony Field
		2.800	1.31	C-OF					
2	138.78	0.001		P			R. L. Peneto, et al	7-7	Discovery Well, Lakeview Field
3		6.500	16.00	C-OF			Humble	4-29	Discovery Well, Freestone Field. Deepest well drilled in East Texas.
4	193	0.017		P			Standard of Texas	7-19	Discovery Well, East Sherman Field.
5		16.000	26.04	C-OF			Atlantic	12-14	Discovery Well, North Lansing Field.
6	230.46	0.001		10/64	200	250	R. R. Fair	7-6	Discovery Well, Walter Fair Field.
7		47.000	4.73	C-OF			Humble	5-31	Discovery Well, Trawick Field.
8		12.000	3.00	C-OF			T. Weiner, et al	11-9	Discovery Well, Weiner Field.
9	309.43	0.045		1/2	Packer	40	A. O. Phillips	10-5	Discovery Well, Bud Lee Field.
10	320.54	0.284		1/4	Packer	510	Humble	3-16	Discovery Well, Red Springs Field.
		1.500	86.67	1/4	Packer	1,510			
11	331.15	0.066		P			Coats & Moore	10-3	Discovery Well, Pewitt Ranch Field.
12	22	x		P			Bert Fields	4-10	Discovery Well, Coats Field.
13	30.25	x		P			F. R. Jackson, et al	7-12	Discovery Well, Mineola Field.
14	107.92	0.002		P			Bobby Manziel	6-28	Discovery Well, Nolan Edwards Field.
15	231	0.077		1/4	170	165	F. R. Jackson	10-8	Discovery Well, Pine Mills Field.
16		1.500	24	3/8	750	645	Tide Water-Seaboard	1-26-47 [1]	Discovered Bodessa Gas Zone.
17		9.50	26	C-OF			Carter Gragg	12-30	New Pay Zone.
18		2.20	20	C-OF		965	Lone Star Prod. Co.	4-20	New Pay Zone.
19	113.61	0.395		Gas Lift	1,575	890	Lone Star Prod. Co.	7-28	Discovered Oil in the Woodbine.
20	25.4	0.005		3/8	Packer	180	Delta Drilling Co. and Chicago Corp.	5-30	Discovered Oil in Lower Glen Rose. (Pettit).
21	15.19	0.020		P			Humble	10-7	Discovered Oil Zone in Huxley Field.
22		2.90	86	1/4			Phillips	1-26	New Pay Zone.
23	20.9	x		P			Shell Oil Co.	8-19	Extension 1 ½ mi. South.
24	237	0.021		1/4	275	310	Amerada	7-23-42 [1]	Discovered Oil Zone in Bodessa.

TABLE 5 - OIL PRODUCTION DATA ON MAJOR PRODUCING FORMATIONS

LINE NO.	FIELD	COUNTY	YEAR OF DISCOVERY	OIL PRODUCTION THOUSANDS OF BBL: 1949	CUM. 1-1-50
	Woodbine (Active 1-1-50)				
1	East Texas	Cherokee, Gregg, Rusk, Upshur and Smith	1930	93,527	2,669,230
2	Hawkins	Wood	1940	11,454	107,842
3	Van	Van Zandt	1929	8,275	203,016
4	Cayuga	Henderson, Anderson, Freestone	1934	1,908	43,154
5	Long Lake	Anderson, Freestone	1933	1,220	17,068
6	Mexia	Limestone	1920	379	101,632
7	Powell	Navarro	1923	359	114,745
8	East Long Lake	Anderson	1941	228	1,903
9	William Wise	Cherokee	1946	90	353
10	Wortham	Freestone	1924	81	23,564
11	Navarro Crossing	Houston	1938	74	1,337
12	Lone Star	Cherokee	1938	74	703
13	Pleasant Grove	Rusk	1941	53	591
14	Boggy Creek	Anderson, Cherokee	1925	44	4,427
15	Quitman	Wood	1948	35	44
16	Weiland	Hunt	1942	21	941
17	Currie	Navarro	1921	18	7,121
18	Others [2]			82	8,075
19	Sub-Total			117,922	3,306,136
20	Inactive (1-1-50) [3]			0	3,356
21	Total Woodbine			117,922	3,309,492
22	Percentage of Total District Production			84.4	92.1
	Paluxy (Active 1-1-50)				
23	Talco	Titus, Franklin	1936	6,165	116,822
24	Quitman	Wood	1942	1,953	14,614
25	Sulphur Bluff	Hopkins	1936	731	17,606
26	Sand Flat	Smith	1944	542	2,544
27	Manziel	Wood	1943	501	3,572
28	Coke	Wood	1942	397	3,038
29	Mitchell Creek	Hopkins	1948	85	105
30	Tyler	Smith	1948	82	89
31	Mt. Sylvan	Smith	1946	71	315
32	Boynton	Smith	1946	40	216
33	Walter Fair	Kaufman	1949	32	32
34	Lakeview	Franklin	1949	24	24
35	Chapel Hill	Smith	1940	21	50
36	Campbell	Hunt	1943	20	249
37	Pewitt Ranch	Titus	1949	20	20
38	Bud Lee	Smith	1949	9	9
39	Total Paluxy			10,693	161,305
40	Percentage of Total District Production			7.7	4.5

[2] Includes Richland, Quitman, Flag Lake, Tehuacana, Normangee Flynn, Honest Ridge, Reed, Southern Pine, Weches.
[3] Includes Cedar Creek, Nigger Creek, Rusk, Buffalo, Oakwood, Manziel, Percilla.

FIG. 1 - OIL AND GAS FIELDS - EAST AND EAST CENTRAL TEXAS

The Drift of Things

. . . as followed by **EDWARD H. ROBIE**

Secretary AIME

Probably a Local War

Most students of the Russian situation seem to think that the Korean war will not extend beyond that country. If that proves true, the mineral industry need not anticipate more than a temporary fillip in the demand for its products. None of the controls and allocations of World War II seem likely. Considerably more power than has yet been exerted will be necessary to push the North Korean aggressors back into their own country, but the consumption of war material should not be large. However, the same type of outbreak may be expected from time to time in several other Communist-dominated countries so United Nations forces must be more ready than they were in Korea to oppose force with force. This will mean that a larger proportion of the world's mineral output would be utilized for munitions even though they were not immediately consumed.

The present situation indicates the need for a better organized United Nations police force. Some plan should be ready for execution whereby forces from member countries can be immediately dispatched to areas where trouble threatens or military force must be opposed. The United States cannot and should not police the world. The war in Korea had to be assumed for the present by the United States alone, even though it was voted by the United Nations, but it would further the conception of the United Nations idea if no nation, and especially the United States, completely dominated such an effort.

Also, the veto power in the United Nations in such cases as this should be removed. Though Soviet Russia has been blamed for using it to excess, the United States, when the United Nations was organized, was one of those that insisted on this provision in the charter. It was only luck that the Soviet representatives, pouting about the non-representation of Communist China, were absent when the Security Council voted that North Korea, as an aggressor, should be opposed. Had they been present the vote of censure would have been vetoed. No nation should have the power to veto action just because its own interests are concerned. This is just the time when world opinion should govern.

Proponents of world government have long advocated codification of international law. Such law is badly needed in the present instance. It would certainly define what is meant by "aggression." By the Russian definition, the South Koreans or the Americans — it is not entirely clear which — were the aggressors in Korea, cruelly attacking the peaceful inhabitants of North Korea. If this was true it was indeed fortunate that North Korea had immediately available an overwhelming military force that could overrun the aggressor's country as soon as they had fired the first shot across the border.

Will You Help?

All organizations like to grow. It is an indication of health and good management. Growth normally results in greater economy of operation, increased welfare of the staff, greater profits to the stockholders, and better and cheaper products for the customers. These factors apply equally to a company owned by stockholders or to a cooperative enterprise like the AIME. With the AIME however, the members are the stockholders and get the profits, tangible or intangible, achieved by growth. The members are also, to a large extent, the customers, getting the benefit of lower unit costs on larger production.

Though the Institute has had remarkable growth — from 7,868 members at the beginning of 1934 to 16,344 at present — the membership could easily be 20,000. A more powerful organization, with greater prestige, would result. Meeting attendance would increase, and thus the opportunity for more professional contacts. The financial benefits would be equally great. If 4,000 new members were added to the rolls in the next year, and 3,000 of them were Associate Members and Members, there would be an increased income of $60,000 in initiation fees and a like amount in dues. If the other 1,000 were Junior Members without initiation fees, another $12,000 would be added, or $132,000 in all. The expense of servicing these additional 4,000 members would be nothing like $132,000. The difference would mean increased services and privileges, at a lower cost to members.

Not only would the income from fees be increased by the amount stated, but the circulation of the journals would be expanded by a like amount. This would make them more valuable to advertisers, and higher advertising income should result.

In the last month every member has been asked by mail to suggest the names of good prospects. It is hoped that this request will be productive of a large number of names, of which a good proportion will eventually be found in the Directory. Still more appreciated will be the succesful effort of a member to obtain a formal application for membership. If you do not have a blank, just ask us for one when you send in the card.

There is no better way in which AIME members can feather their own professional nest. So send in that card — or a filled out application — now, if you have not already done so.

New Type of Ore

Credit Giant Yellowstone Gold Mines, up on the shore of Great Slave Lake in Canada, with an entirely new type of gold occurrence, which is being commercially mined. Water, as is well known, is a mineral, and sea water is a commercial "ore," containing iodine, magnesium, and other things, whose extraction is commercially practicable. But fresh-water ice is ordinarily deficient in "values," except those that are inherent in its use for cooling purposes. At the Giant property, however, ice has been found in considerable quantity that contains particles of free gold, enough so that the ice is mined for their recovery. This may have been done elsewhere, but we have never heard of it. Alaskan gold gravels are of course, often found frozen and the placer ground must be thawed before the gold is won, but that is somewhat different. ★ ★ ★

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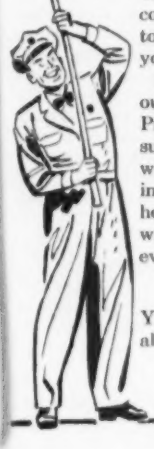

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Replies to the positions coded Y-3429 and Y-3740 and to the personnel coded M-554 below should be addressed to: Engineering Societies Personnel Service, 8 West 40th St., New York 18, N. Y. The ESPS, on whose behalf these notices are published here, collects a fee from applicants actually placed.

POSITIONS

♦ Petroleum engineer, proficient in mathematics, with wide experience in oil and gas reservoir engineering on primary and secondary recovery; should be familiar with problems and methods concerned with reservoir analysis. Work is associated with a wide range of technical service reservoir problems in well-equipped production research laboratories. Duties include preparation of basic field production and reservoir data for application in analogue and digital computers, and interpretation and preparation of resulting data for reservoir engineering reports on specific fields. Location: Field Research Laboratories of Magnolia Petroleum Co., Dallas, Tex.

♦ Project engineer, 30-40, experienced on petroleum and/or gas equipment. Must be able to assume supervision of, and responsibility for, entire section. No recent graduate considered, as position entails immediate responsibility. Location, Pennsylvania. Y-3429.

♦ Engineers qualified to do research in petroleum production, preferably graduates in petroleum engineering; graduates in other curricula having some familiarity with petroleum production and more than average background in mathematics or physics will be considered. Opportunity to work toward an advanced degree. Salary, $3,000-$4,500 a year, higher for a particularly well qualified man. Location, Pennsylvania. Y-3740.

PERSONNEL

♦ Geologist, 1949 graduate, veteran, 27, married, seismograph and surveying experience, desires position in exploration, production, or land department of petroleum company. Code 135.

♦ Geologist, B.S., desirous of gaining experience any phase of the field. All other factors and location immaterial. M-554.

♦ Experienced oil man wants connection. Seven years with major company. Petroleum engineer and production foreman. B.S. and M.S. degrees from California Institute of Technology. Age 35. Healthy, married, good habits, best references. Code 136.

♦ Recent graduate in petroleum engineering from University of Tulsa desires production and/or engineering work with domestic or foreign oil producing company. Now working with oil well cementing company, age 25, single, three years military service, B.S. degree. Code 137. ★ ★ ★

Unitization

Continued from Page 13, Section 1

ing rules it would seem clear that the lessee cannot escape liability asserted by merely proving the impracticability of protecting against drainage resulting from its own operations. Unitized operation would call for fewer wells than if the field were developed competitively. The lessor whose land was thus neglected could complain of a breach of obligation to develop, and his contention would be just, since his neighbors, through whose wells production from his land might be diverted, could not be compelled to share royalties with him. Although some leases authorize unitization, these provisions do not usually take care of most of the problems and if any effective unitization is desired, new agreements are usually required.

Kline believes that it is within the police power of the state, within constitutional limits, to provide the means whereby unitization can become a reality in order to prevent waste, achieve greater ultimate recoveries of natural resources, protection and full enjoyment of correlative rights of several owners of an oil and gas pool, and the advancement and economic stabilization of a basic industry essential to the general welfare. The Oklahoma unitization statute provides that the unit operation must be on terms which are fair, reasonable and equitable, and which protect, safeguard and adjust the respective rights and obligations of the several persons affected.

Kline concluded with the following summary:

1. Much progress has been made in working out unit projects and and developing a tolerance toward compulsory unit operations and compulsory unit statutes.

2. The rule of capture has been modified by regulation in many states and it is anticipated that California will soon enact a conservation law.

3. It is unlikely that the courts will hold that unit operations are in violation of antitrust laws if the unit operations are designed to prevent waste and protect correlative rights.

4. There are no tax disadvantages in unit operations which cannot be avoided or obviated by proper draftsmanship.

★ ★ ★

Water Flood

Continued from Page 14, Section 1

ences the results, and that the magnitude of optimum pressure gradients may be considerably different for different areas.

For a given well spacing the correct pressure gradient is chiefly a function of the size and distribution of the sand pore constrictions, modified to some extent by the depth of the sand, the oil saturation, and the desired life of the flooding operation. Research workers should attempt to develop techniques for determining the best pressure gradients for given sand and field conditions. Another case where simulation of field conditions and laboratory research are equally important include the magnitude of base exchange reactions between various flood waters and the clays associated with oil sands. In this respect it is apparent that performance depends upon treatment of the core material prior to the test and testing procedure.

Eventually it will be realized that efficient water flooding practices used in Bradford are not applicable everywhere. Hughes claimed that in California, from 10 to 25 billion bbl of oil in presently discovered fields will not be recovered by current primary production practice. The degree to which this oil can be recovered depends largely upon prompt and adequate water flooding research simulating the conditions encountered in the various California sands. ★ ★ ★

Personals

L. B. Meaders and Ralph R. Emery have been appointed vice-presidents in charge of field operations and foreign operations respectively of Halliburton Oil Well Cementing Co. Wilfred Tapper was elected vice-president of electrical well services and W. D. Owsley was elected vice-president and technical advisor to executive officers. Grover Kilgore was elected vice-president in charge of sales and advertising.

OWSLEY

MEADERS

Foster L. White is now assistant chief, technical branch, petroleum committee, Munitions Board, Washington, D. C.

+

Frank McKinless has been appointed manager of the Detroit office of the Engineering Societies Personnel Service, Inc. A graduate of the Colorado School of Mines, he has more than 25 years' experience in the design, production, sales and management fields.

+

Harold Robert Sells, recently reservoir and evaluation engineer for Sohio Petroleum Co., Oklahoma City, Okla., has joined the firm of Amstutz and Yates, Inc., consulting engineers and geologists of Wichita, Kansas. Prior to joining Sohio, he served on the University of Kansas faculty as a petroleum engineering instructor. He has spent the greater part of his career practicing in the Mid-Continent area, at one time serving as secretary of the Oklahoma City Section of AIME.

Wallace R. McClendon has been appointed president of Halliburton Oil Well Cementing Co. He has been vice-president in charge of field operations since 1942. He replaces retiring president John C. Halliburton.

+

John R. Brack has been made petroleum engineer of the Ohio Oil Co., Midland, Tex. He was formerly junior petroleum engineer.

+

J. H. Pollard has opened offices as a consulting engineer in Houston, Tex. He has held positions for 25 years ranging from junior engineer to chief engineer in the non-metallic mineral-industry.

+

Gail F. Moulton, staff geologist in the Petroleum Department of the Chase National Bank since 1943, has been elected second vice-president of the bank. He has served as vice-president of the Petroleum Branch, AIME, and also as a director of the Institute. He now makes his home in Mountain Lakes, N. J.

+

Charles F. Weinaug has been promoted from associate professor to professor of petroleum engineering at the University of Kansas. He is also chairman of the department and has been at the university since September, 1948. At the same time, E. L. Anders, Jr., has been promoted from assistant professor to associate professor of petroleum engineering at KU.

+

Donald H. McLaughlin, president of the AIME and the Homestake Mining Co., and J. A. Martino, president National Lead Co., were among those who received citations at the Boston Jubilee.

W. O. Keller, formerly reservoir engineering supervisor of Stanolind Oil and Gas Company, Tulsa, Okla., is now affiliated with the consulting firm of Keller and Peterson of Midland, Tex. He joined Stanolind in 1941 and spent a number of years in field engineering work in West and East Texas. He also is affiliated with the firm of McMillian, Keller & Peterson, dealing in oil properties.

+

Philson D. Collins, Jr. is now located in the New York office of the Arabian American Oil Co. in the producing, pipe lines and transport department. He was formerly district petroleum engineer in the Dhahran district, Saudi Arabia.

+

Pete W. Cawthon, Jr. is now employed as evaluation engineer in the oil and gas department of the City National Bank, Houston, Tex. Previously he held the position of reservoir engineer with Phillips Petroleum Co., Midland, Tex.

+

Keith Thompson Webb has taken a position as field geologist with Continental Oil Co., Morgan City, La., following his graduation.

+

Theodore A. Link has formed a partnership with Arthur W. Nauss as oil and gas appraisers, exploration consultants, etc.

+

John C. Papp has joined J. R. Butler & Co., Houston, Tex., as consulting petroleum engineer.

+

W. F. Hamilton has resigned his position as district geologist with the Gulf Refining Co., Laurel, Miss., to enter private consulting work. He is now located in Jackson, Miss.

FLOOD WATER TREATMENT

Continued from Page 3, Section 1

system is employed. The introduction of air oxidizes soluble iron and, in a brine medium, dissolved oxygen is particularly active in causing corrosion. Finally, the very high concentration of all salts affects the equilibria involved and constitutes a special problem in water treatment.

Brines may be divided into two groups, those of high and low *pH*. The former contain the carbonates of sodium and potassium which hydrolyze to give very small amounts of the corresponding hydroxides. These brines are low in calcium, magnesium and iron but may be high in sulfates. Aside from the difficulties experienced with emulsified oil, such brines are not too difficult to treat.

Low *pH* brines are high in iron and sometimes manganese and contain large quantities of the bicarbonates and sulfates of calcium and magnesium. Equilibrium is reached in these brines at relatively low values of *pH* and the complete removal of iron and manganese offers a problem of considerable complexity.

Table VI shows the mineral analysis of a produced water which has an iron content too high for use without treatment. Chlorine serves the dual purpose of oxidizing the iron and removing any hydrogen sulfide present. No other treatment is used except the addition of a small amount of complex phosphate.

DISSOLVED OXYGEN

One precaution needs to be considered in connection with all types of supplies. Oxygen dissolved in water acts as a corrosive medium, more active in some instances than in others, but always a serious problem. If possible, all supplies should be protected from aeration by cascading during production and treatment. The rate at which oxygen dissolves when a stream drops through the air even for a short distance is much more rapid than would be anticipated. The presence of cascading streams or thin sheets of water will most assuredly increase the oxygen content to a point where corrosion will be a matter of serious consequence. Aeration as a means of oxidation of iron and manganese introduces the same problem. The prevention of intimate contact between the water and the atmosphere will eliminate corrosion through oxygen and with it many perplexing problems.

Many deep well waters are oxygen free and if a properly engineered and installed mechanical pump is used to produce the water, the supply may be maintained in this condition. Streams and ponded supplies, on the other hand, contain varying quantities of dissolved oxygen. To remove this, it is necessary to make use of a deaerating tower. Many of these have been in use over a period of years and afford a satisfactory method for the removal of a large proportion of the oxygen. A small amount of oxygen may be deactivated by the use of sodium sulphite or sodium nitrite, preferably the former since the product from the oxidation of sodium sulphite is sodium suphate, a normal constituent of the majority of waters.

SUMMARY

The examples presented here are typical of the wide variety of waters which are encountered in the field. The method of treatment must be varied with each individual water, depending upon the character and amount of the impurities present. To obtain satisfactory performance, the treatment needs the supervision of competent and experienced engineers basing their control upon the results of regular laboratory examination. Such a program will go a long way toward securing the maximum yield of oil possible through water flooding as a means of secondary recovery. ★ ★ ★

A MEMORIAL TO CHARLES B. CARPENTER

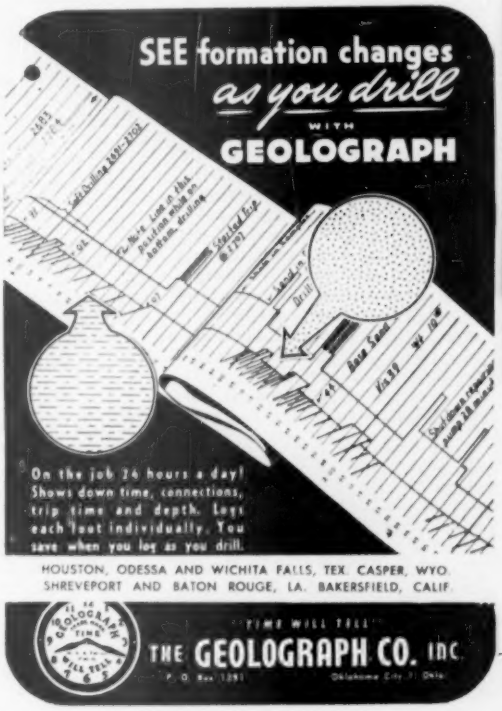
The Executive Committee of the Petroleum Branch is acting upon a Memorial Resolution in tribute to Charles B. Carpenter following his untimely death June 10, 1950.

The Branch pays the following tribute to his memory, and extends the deep sympathy of every member to his family.

BE IT RESOLVED, that this Memorial be placed in the records of the Branch and the Institute, and a copy be given to Mrs. Anna T. Carpenter, his mother, and to Mrs. Eunice Wells Carpenter, his wife.

Chairman-elect of the Branch for 1951, Charles Carpenter would have assumed next year the position due him for his many years of active participation in the affairs of the AIME. Death deprived the Branch of a formidable leader. In tribute to his passing his friends have established a Memorial Fund at Southern Methodist University which will be used either for outright scholarship purposes or as an endowed scholarship. At this writing, the amount in the fund had risen to $2,120.50, a figure indicative of his popularity.

Charles Carpenter was distinguished as a petroleum engineer and geologist from 26 years of service in the professions, as an executive in the U. S. Bureau of Mines in Dallas, and as an author of technical papers and publications.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Proposed for Membership
Petroleum Branch

Total AIME memberships on Mar. 31, 1950, was 16,397; in addition, 4,037 Student Associates were enrolled.

ADMISSIONS COMMITTEE

E. C. Meagher, Chairman; A. J. Phillips, Vice-Chairman; George B. Carless, John T. Sherman, Lloyd C. Gibson, R. D. Mollison, Plato Malozemoff, Ivan Given.

Institute members are urged to review this list as soon as the issue is received and immediately to wire the Secretary's office, night message collect, if objection is offered to the admission of any applicant. Details of the objection should follow by air mail. The Institute desires to extend its privileges to every person to whom it can be of service but does not desire to admit persons unless they are qualified.

In the following list C/S means change of status; R, reinstatement; M, member; J, Junior Member; AM, Associate Member; S, Student Associate; F, Junior Foreign Affiliate.

CALIFORNIA

Fullerton—Baker, John S. (M).
Huntington Park—McArthur, Ralph F. (M).
Long Beach—Aggers, Harry D. (C/S-J-M).
Meyers, Paul W. (R, M).
Los Angeles—Trobaugh, Allen K. (R, C/S-S-J).
Ventura—Huffman, Dean R. (J).

COLORADO

Denver—Murdoch, Jesse B., Jr. (M).
Rangley—Thornton, James T. (R, C/S-S-J).

LOUISIANA

New Orleans—Smith, Winston G. (A).

MISSISSIPPI

Laurel—Tipps, Jake B. (A).
Natchez—Kiser, John W. (M).

MONTANA

Butte—Parfitt, Paul A. (J).

NEW JERSEY

Madison—Koebel, Frank E. (A).

OKLAHOMA

McAlester—Puterbaugh, Jay G. (R, C/S-A-M).
Tulsa—Farris, Riley F. (M).

PENNSYLVANIA

Pittsburgh—Ballord, Clarence W. (M).
Punxsutawney—Hampton, William H. (C/S-A-M).

TEXAS

Beaumont—Buchanan, Fred E. (J).
Borger—Allis, Dean H. (C/S-S-J).
Corpus Christi—Webb, Austin C. (J).
Dallas—Thurman, Earl G., Jr. (C/S-S-J).
Livingston, Mickey M. (M).
Henderson—Williams, Don M. (J).
Houston—Brinkerhoff, Ira A. (M), Dickinson, Walter H. (M), Fox, Fred K. (C/S-S-J), Greer, Walton J. (M), Martin, Earl P. (A), Olson, Mark O. (R, C-S-S-M).
Kermit—Horton, Harry L. (C/S-S-J), Monzingo, Arthur J. (J).
Midland—Ross, Jesse J., Jr. (J), Wendt, Herman E. (C/S-S-J).
Odessa—Priebe, Franklin D. (R, C/S-S-M).
Silsbee—Penrod, John M. (C/S-J-M).
Tyler—Evans, Billy W. (J).

VENEZUELA

Jusepin—Edison, Thomas O. (J).

INDONESIA

Sumatra—Sears, Roy C. (J).

Instruments

Continued from Page 15, Section 1

surveys stem from the application of the instrument to well. In certain cases it is necessary to remove tubing and equipment to run the instruments. In high pressure work there is the added problem of lubricating the tools into the well. Results are limited by the threshold velocity of the spinners, ordinarily around one to two ft per second. Interpretation is made difficult by turbulance, heading effects, gas expansion, and variation in velocity due to changes in hole size and variations in areas open to flow behind the liner. Sheldon noted, however, that the incorrect interpretation is the exception rather than the rule, and that generally speaking spinner surveys are easier to interpret than temperature surveys.

Another valuable analysis method is the permeability survey conducted through the use of an electric pilot. The tool itself consists of exposed electrodes insulated from each other. When the tool is surrounded by electrolyte a circuit is completed through the "shooter's line" to the surface. By injecting electrolyte into the well at some constant rate, and following the oil-electrolyte interface with the pilot, it is possible to determine the position and relative importance of various permeable zones in terms of thickness and relative capacity. Various indices can then be developed to give some measure of relative permeability.

One problem involved is the necessity for having tubing above the zone while running the tool. Also, the use of certain electrolytic solutions may be deleterious to the formation under study. Sheldon emphasized, however, that there are ways to minimize these objections, and that the survey has many useful advantages. He particularly recommended the survey for wells planned for injection use in secondary recovery projects.

Sheldon touched upon water locating tools, subsurface samplers, lubricating devices, Amerada chart readers, and tubing bailers, all of which have their place in reservoir work. He particularly emphasized the value of the chart reader in improving accuracy and thereby aiding interpretation. His concluding remarks dealt with the problem in all survey work due to debris which collects in well bottoms. In many cases this prevents the engineer from getting his tools to bottom, and, where the small bailers cannot be applied, necessitate extensive well maintenance before complete results can be obtained. As such maintenance work is costly, the engineer must often be satisfied with incomplete data. ★ ★ ★

Mexico City Host To 1951 Meeting

Formal acceptance of an invitation to hold the Fall Meeting of the AIME in Mexico City in October 1951 was voted by the Board at its meeting on June 22. The invitation was first tendered at the Annual Meeting last February, by Ing. Raul de la Pena, director general of the Instituto Nacional para la Investigacion de Recurcos Minerales. Several other societies covering the mineral technology field have also been invited by Pena to participate.

This will be the first AIME meeting to be held outside of the United States since the 146th meeting, which also was held in Mexico City, in November 1936. Approximately as many ladies as men attended that meeting, and it is expected that the trip next year will have equal appeal. Several members have already indicated that they plan to take their vacation at that time. A good automobile road is now available from the border to Mexico City, and frequent airplane service also supplements railroad accommodations. A few technical sessions will be arranged but the social features will no doubt be dominant, and several field trips, of professional, scenic, and historical interest, are planned. The dates in October remain to be fixed. That month was selected because it is the most ideal time of the year to visit Mexico City, according to those who know.

Decision was also reached by the Board on several other meetings. The Annual Meeting for 1951 had already been arranged for St. Louis, Feb. 18-22, with the Jefferson Hotel as headquarters. The 1952 Annual Meeting will be back in New York City, Feb. 17-21, with the Statler as headquarters, but the banquet will be held at the Waldorf-Astoria, Feb. 20. The Fall Meeting in 1952 will be held in Chicago in connection with the Centenary of Engineering being arranged by the American Society of Civil Engineers to commemorate its 100th anniversary. Several other national engineering societies will hold important meetings at the same time—the period between Sept. 3 and 13. In 1953 the Annual Meeting will be held in Los Angeles, Feb. 15-19, with the Statler Hotel as headquarters. Construction of this latest link in the Statler chain is to begin immediately and it should be ready for occupancy by early fall of 1952. ★ ★ ★

A MORE LIBERAL POLICY ADOPTED AT AIME BOARD MEETING

Revisions in the methods of naming the Nominating Committee and electing Directors were completed at the June 22 meeting of the Board, when new bylaws to give effect to the recommendations of the Peirce committee were passed. The new bylaw is essentially the same as the text published in the June issue of PETROLEUM TECHNOLOGY except that the Council of Section Delegates and the three Branch Councils must appoint an alternate for each member named to the Nominating Committee, so that if the principal is unable to attend the meeting of the Nominating Committee at the Annual Meeting, an alternate can be called upon.

The Nominating Committee will name a President-elect, who will serve one year as Director before becoming President, two Vice-Presidents, and six other Directors, all nine men being Directors for three-year terms. Provision is made that each of nine of the ten districts in which the country is divided is entitled to one Director on the Board to represent its interests; a tenth district, the New York metropolitan area, is entitled to six Directors to assure a quorum at Board meetings. A fair representation of Directors among the Mining, Metals, and Petroleum Branches is also an aim.

Official announcement was made at the June 22 Board meeting of the selections made by the Nominating Committee for Institute officers for 1951, as published in the May issue of PETROLEUM TECHNOLOGY. A ninth candidate to add to the official ticket was selected by the Board, namely Leo F. Reinartz, assistant vice-president of the Armco Steel Corp., Middletown, Ohio, who was chosen for a three-year term as Director. Reinartz was born in East Liverpool, Ohio, Aug. 3, 1888. Carnegie Tech. granted him Bachelor of Science and Metallurgical Engineer degrees, and he has worked for the American Rolling Mill Co. and its successor, Armco Steel, ever since he graduated in 1909. Successively he has been chemist, assistant superintendent of open-hearth departments, open-hearth superintendent, assistant general superintendent, and works manager. He was a Director of AIME from 1943 to 1948, serving as Vice-President the last three years.

Liberalization of the Institute's policy on controversial matters was voted by the Board at its meeting, June 22. Some members of the Institute had felt that the policy heretofore followed had been too narrow. Recently (Feb. 12, 1950), the executive committee of the Mineral Economics Division had specifically asked the Board to endorse a proposed resolution whereby the Board could make known "facts and views on matters affecting the mineral economy of the nation . . . relating to national defense, provision of adequate peacetime mineral supply, and conservation and development of mineral resources." The Board did not wish to go as far itself as was suggested by the Mineral Economics Division, but at its June 22 meeting passed the following resolution:

WHEREAS, one of the purposes of the American Institute of Mining and Metallurgical Engineers is, according to its constitution, "to promote the arts and sciences connected with the economic production of the useful minerals and metals, and the welfare of those employed in these industries by all lawful means;" and

WHEREAS, the Mineral Economics Division of the Institute feels that the policy enunciated at the meeting of the Board of Directors on Feb. 21, 1933 "to refrain from official participation or action in controversial nontechnical economic subjects" is unduly restrictive; therefore be it

RESOLVED, that Branches, Divisions, and Local Sections of the Institute be encouraged to hold meetings, symposiums, and forums, and to publish papers in the Institute journals as desired, for the objective discussion of subjects pertaining to the economic welfare of the mineral industry and those employed therein, both in the United States and abroad; and that reports of such discussions be made available as desired to public agencies; but that neither the Institute nor its Branches, Divisions, Local Sections, or official representatives shall adopt an official position on such matters. This, however, shall not be regarded as a rigid prohibition against an expression of opinion by the Board on matters pertaining to the mineral industries that are of vital interest to the nation in times of danger. ★ ★ ★

Members Urged to Improve Their Status in AIME

Many Institute members holding responsible professional positions are classed as Associate Members rather than Members. This is usually because of the fact that when they applied for membership their qualifications were not such that they could be elected as Members. To qualify for the latter category, one "must have had at least six years' employment in the practice of mineral engineering, or in the application of the sciences to any of the branches of the mineral industry, during at least three years of which he must have held positions of responsibility."

Associate members are urged to apply for a change of status to Member as soon as they feel qualified. The prestige of being a Member well justifies the change. No cost is involved, and all fees and privileges are the same. Merely notify AIME headquarters that you wish to apply for the change in status and an application blank will be sent you. Or if you have one of the regular application blanks for membership, merely fill it out and mark it change in status. ★ ★ ★

COASTAL WORKS STUDY SET IN CALIFORNIA

A three-day institute on coastal engineering will be held in Long Beach, Calif., October 11-13, sponsored by the departments of engineering and the Division of Engineering Extension of the University of California at Berkeley and UCLA.

The purpose of the institute is to summarize in a concise form the present status of usable information and techniques for the benefit of practicing engineers engaged in the design, construction, operation, and maintenance of coastal works. Recognized authorities and experts throughout the nation will present papers and engage in panel discussions. ★ ★ ★

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PETROLEUM BRANCH MEETING CALENDAR

AUGUST Through JANUARY

AUGUST

10	Pacific Junior Group
17	South Plains Sub-Section
28	Pacific Petroleum Chapter

SEPTEMBER

7	Illinois Basin Chapter
11	Mid-Continent Section
12	Delta Section
13	Southwest Texas Section
14	Pacific Junior Group
19	Gulf Coast Section
20	Kansas Section
21	South Plains Sub-Section
21	Oklahoma City Section
22	Mississippi Sub-Section
25	Pacific Petroleum Chapter
25	Permian Basin

OCTOBER

4-6	**Petroleum Branch, AIME, New Orleans**
5	Illinois Basin Chapter
9	Mid-Continent Section
9-13	Mineral Economics Division, Washington, D. C.
11	Southwest Texas Section
12-13	**Petroleum Branch, AIME, Los Angeles**
17	Gulf Coast Section
18	Kansas Section
19	South Plains Sub-Section
19	Oklahoma City Section
23	Pacific Petroleum Chapter
30	Permian Basin

NOVEMBER

2	Illinois Basin Chapter
8	Southwest Texas Section
13	Mid-Continent Section
14	Delta Section
15	Kansas Section
16	South Plains Sub-Section
16	Oklahoma City Section
21	Gulf Coast Section
27	Pacific Petroleum Chapter
27	Permian Basin Section

DECEMBER

1	Mississippi Sub-Section
7	Illinois Basin Chapter
11	Mid-Continent Section
12	Gulf Coast Section
12	Delta Section
14	Pacific Junior Group
20	Kansas Section
21	South Plains Sub-Section
21	Oklahoma City Section

JANUARY, 1951

4	Illinois Basin Chapter
8	Mid-Continent Section
9	Delta Section
10	Southwest Texas Section
17	Kansas Section
18	Oklahoma City Section
22	Pacific Petroleum Chapter

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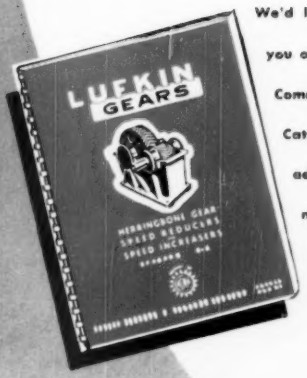

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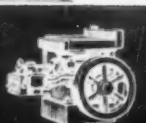

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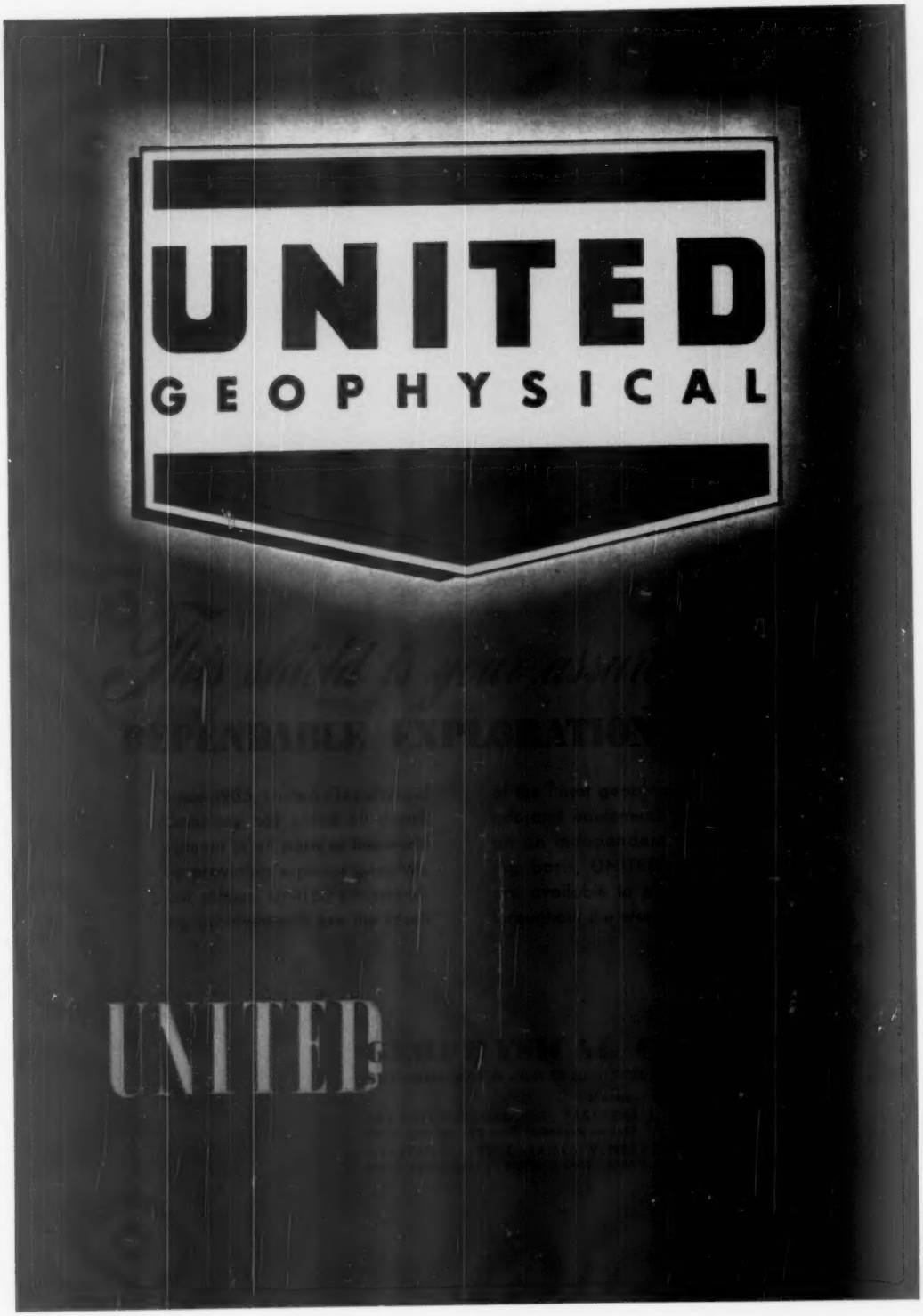
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